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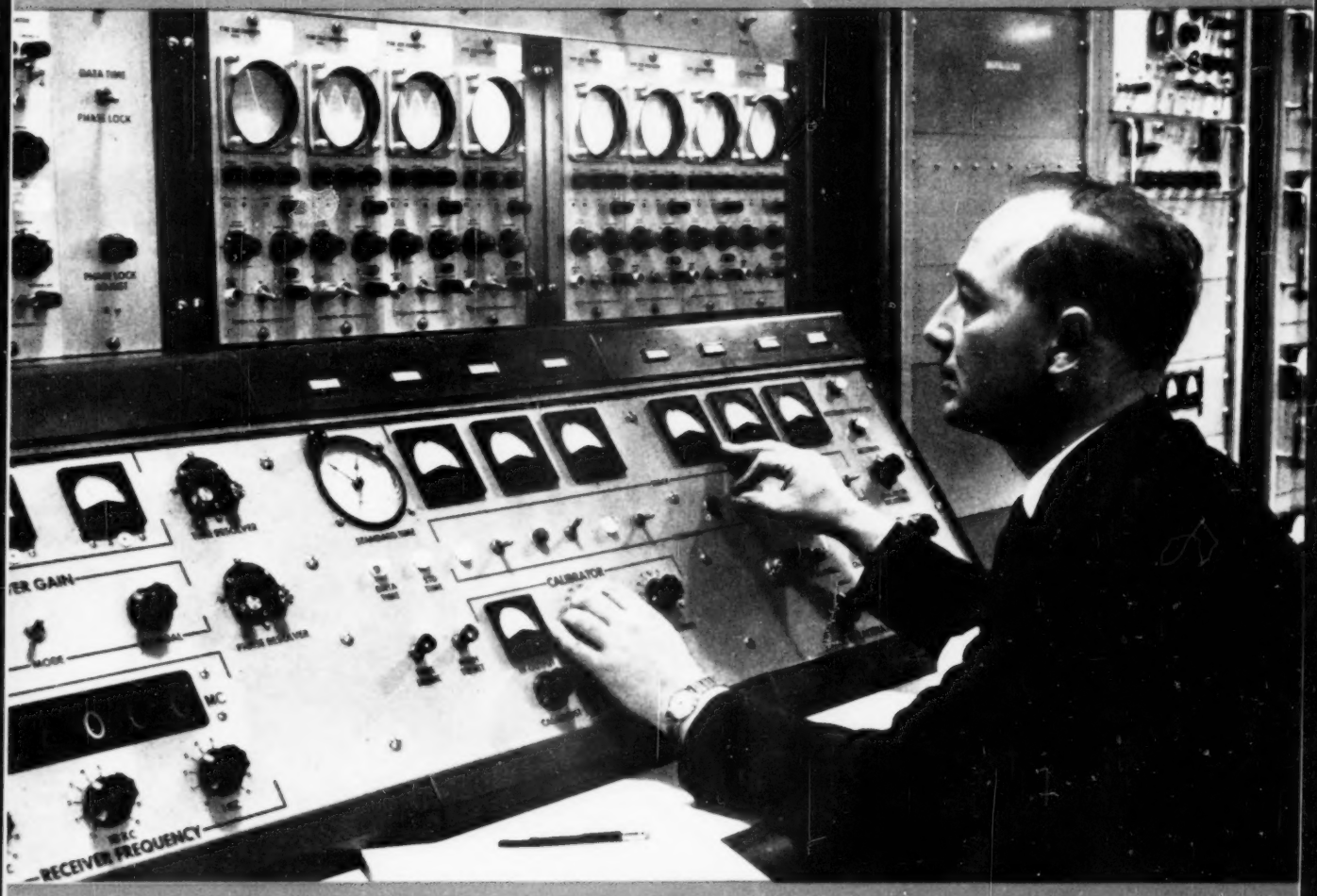

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SPACEFLIGHT

Volume III July 1961 Number 4

THE MAGAZINE OF AEROSPACE SCIENCE AND TECHNOLOGY

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COVER

The control console for the Minitrack interferometer system. Equipment for producing standard frequencies and timing pulses is shown in the background. The Minitrack station at Winkfield in Berkshire is operated by personnel of the Radio Research Station of D.S.I.R.

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First Men in Space

Although the ballistic flight performed by Cdr. Alan B. Shepard in a Mercury capsule on 5 May did not match in technical accomplishment the full orbital mission of Major Gagarin 23 days before, it *was* an outstanding achievement. The sub-orbital test took the 2250 lb. spacecraft to a height of 115 miles and 302 miles downrange from Cape Canaveral and showed in convincing manner the ability of a human pilot to control the orientation of his spacecraft under weightless conditions. It was also a convincing demonstration of the fibre of the astronaut himself who, as it turned out, had to remain in his capsule for more than 4 hr. before the launching was made.

With the first sub-orbital human test-flight safely accomplished, N.A.S.A. plans to make another test on or about 20 June, following this with a third firing some 6 weeks later. Meanwhile, further attempts will be made to launch unmanned capsules into orbit containing a dummy astronaut and later a chimpanzee. The first attempt to orbit a "breathing, sweating and talking" robot failed at Cape Canaveral on 25 April when the Atlas booster refused to follow the desired programmed path after lift-off and had to be destroyed by the range safety officer. Nevertheless, the capsule itself made a perfect emergency separation under the impulse of the tower-mounted escape rockets, coming down gently in the sea beneath its parachute.

The background to Major Gagarin's orbital mission on 12 April will be found on pages 131–134. Although details of the method employed to re-enter and control the Vostok are still far from complete, it appears that Gagarin was landed by parachute within the pressure cabin of his (ballistic?) spacecraft. In emergency, presumably either during a launching failure or after the re-entry phase near the completion of the flight, he could have been ejected from the spacecraft by means of his ejector seat, which embodied separate parachute recovery equipment.

Further comment on both the Russian and American pioneer experiments will be included in our next issue. Meanwhile, the step by step advance to higher speeds and altitudes by the North American X-15 should not be overlooked. Launched from a modified B-52 bomber at 45,000 ft., the rocket aircraft has already been higher than 31 miles and touched a speed of 3370 m.p.h. It continues the work begun with the Bell X-1, the first aircraft to exceed Mach 1·0 in level flight in 1947, and will lead on to the Dyna-Soar hypersonic glider which the U.S.A.F. are developing to put a man into orbit and return him to Earth under full aerodynamic control.

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Mission to Venus

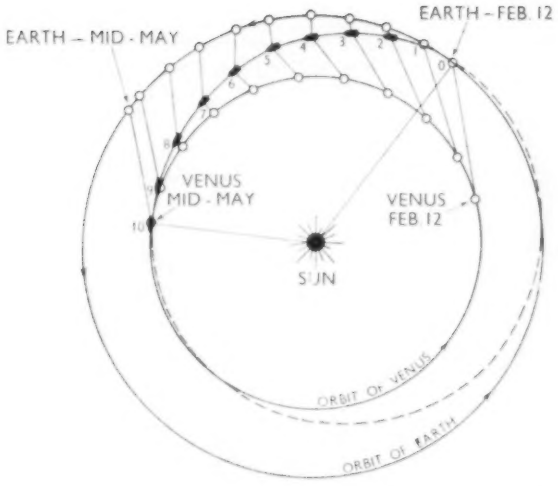
On 12 February the Russians launched an "automatic interplanetary station" on a transfer orbit to the planet Venus. Although radio communication was lost after about 15 days, the experiment is a clear foretaste of further probing missions in store—to Venus and Mars. We are therefore reproducing the major part of the article giving technical details of this project, which originally appeared in Pravda *on 26 February. For the translation, we are indebted to* "Soviet News."

The multi-stage rocket had powerful engines to accelerate it and shoot it to a high altitude above the Earth's surface. The rocket's control mechanism guided it along a path computed in advance. When the rocket reached the orbital velocity, a heavy sputnik carrying a space rocket with the automatic interplanetary station separated from it. The sputnik travelled along an almost circular orbit with a perigee of 6601 km.* and an apogee of 6658 km. from the centre of the Earth. The plane of the orbit was tilted at an angle of 65° to the equatorial plane.

The space rocket took off from the sputnik at a precomputed point on its orbit. When this rocket had attained a velocity that was 661 m./sec.† more than the escape velocity and the rocket had reached a precomputed point in space, the rocket engine stopped and the automatic interplanetary station separated from the rocket to start coasting towards Venus. *This was the first time a guided vehicle had ever been fired in an interplanetary orbit from a sputnik carrier.*

The automatic interplanetary station coasted along an orbit in space shaped by the combined effect of the gravitational pulls of the Earth, the Sun and the planets. The Earth's gravitational pull exercised considerable influence up to a distance of a million kilometres away from its centre, which is conventionally known as its gravitational field. Since the station emerged from this field, it has been mostly the Sun's gravitational pull that has been influencing its movement, in keeping with the same laws that govern the motion of the planets of the solar system.

* *One kilometer* = 0·621 *mile.*
† *One meter* = 3·281 *feet.*



While within the Earth's gravitational field, the station travelled along a curved, practically hyperbolic, orbit, the plane of which passed through the centre of the Earth, and was stationary with respect to the stars, and almost coincided with the plane of the sputnik's orbit. The further the station travelled from the Earth, the less became its velocity in relation to the Earth. When it reached the boundary of the Earth's gravitational field at 11 p.m. (Moscow time) on 14 February, it had a speed of about 4 km./sec. in relation to the Earth.

The station's velocity in relation to the Sun is obtained by calculating the Earth's vector of velocity in relation to the Sun with the station's vector of velocity in relation to the Earth. When the station emerged from the Earth's gravitational field, its velocity in relation to the Sun was 27·7 km./sec.

Since then the station has been travelling like the planets along an eliptical orbit, with a focus at the centre of the Sun, an aphelion of 151 million km., a perihelion of 106 million km., and an inclination of 0·5° to the plane of the ecliptic.

The orbits of the Earth, Venus and the station are almost in the same plane.

Both Earth and Venus move along orbits very close to circular. The positions of the Earth, Venus and the automatic interplanetary station at a given moment of time are connected by straight lines. At the beginning of its movement round the Sun the rocket lags behind the Earth. Shortly before the vernal equinox, the Sun, the station and the Earth will lie approximately on one and the same straight line. After that the rocket will overtake the Earth in its angular motion round the Sun.

The distance from the Earth to the station during the entire flight to Venus will constantly increase, and by the time of approach will reach 70 million km.

The angle between the directions from the centre of the Sun to the Earth, at the moment of the rocket's start, and to Venus at the moment of approach to this planet will amount to 120°. The time of the station's flight to the moment of its approach to Venus will amount to slightly over 3 months. The rocket will approach Venus on 19–20 May, 1961.

Venus, in the same way as the Earth, has its own sphere of influence (with a radius of 600,000 km.). Within that sphere the planet's influence is greater than that of the Sun. The station's motion within this sphere of influence relative to Venus will proceed along a near-hyperbolic trajectory, with its focus in the centre of Venus.

The data obtained from measurements of the orbit show that the station will penetrate deep into Venus's sphere of influence. The minimum distance from Venus to the station, assuming that it moves along its present trajectory, should be less than 100,000 km., with the total distance of the flight from the Earth amounting to 270 million km. And this testifies to the great precision with which the station was placed in its trajectory.

Had the station been a spot shining brightly in space, it would have been possible from the Earth to watch its passage against the motionless stars in the background.

At the beginning of its course the motion of the station relative to the stars was fast. When it left the sphere of the Earth's action, the station was in an area of sky on the border between the constellations of Cetus and Pisces, in the centre of a triangle formed by the stars Beta Arietis, Alpha Pegasi and Beta Ceti. By then the apparent motion of the station on the celestial sphere was small, as the station was travelling in an approximately radial direction relative to the Earth.

The subsequent motion of the station on the celestial sphere resembles the motions of the planets. The station will remain in the constellation of Pisces till the beginning of April in so-called retrograde motion. At the beginning of April the station will be in direct motion on the celestial sphere. The point where the reversal in direction takes place is called the point of reversal. Direct motion among the stars will continue till the moment when the station approaches Venus, which will take place not far from the star Epsilon Piscium.

At the time of the launching of the station, Venus was in the constellation of Pisces and was in direct motion among the stars. The direct motion is gradually slowing down, and at the end of March the reversal of Venus will occur. It will travel in retrograde direction till the beginning of May, when it will again reverse to direct motion. The approach of the station to Venus will take place at this section of the planet's direct motion.

The table below gives estimates of the station's distances from the Earth, Venus and the Sun and its right ascension and declination for every 10 days, counting from the day of launching:

Choice of Trajectory

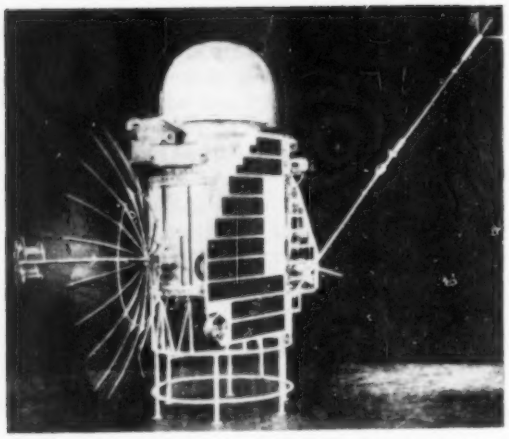
The trajectory of the flight to Venus had to be chosen in accordance with a number of conditions.

If the dates of the start of the rocket and the approach of the station to Venus are fixed, then the orbit of the station in the solar system, beyond the sphere of the Earth's gravity, has a single value. Moreover, the station must enter the sphere of the Earth's gravity at a velocity which is absolutely definite both in magnitude and in direction.

However, if the dates of launching and approach are incorrectly chosen, the magnitude of the required velocity will be so great that the acceleration of a station, even of one with very small weight, will be impossible with the help of the most powerful rockets technically feasible. Therefore, the dates of launching and approach are chosen with a view to ensuring that the required escape velocity is as low as possible. Moreover, the magnitude of the velocity which the carrier rocket is to give to the station in the boost phase will also be minimal.

The method of acceleration of the station by the carrier rocket is also of considerable importance. Given the uninterrupted work of all stages of the rocket, the weight of the payload depends, not only on the magnitude of the velocity which the station has to acquire at the end of the boost phase, but also upon the firing angle. With very big firing angles, the Earth's gravity prevents acceleration. Therefore, it is easier to impart a set velocity in a horizontal direction, whereas big firing

Date (zero hours World Time)	Distance from Earth (million km.)	Distance from Venus (million km.)	Distance from Sun (million km.)	Right ascension Hr.	Right ascension Min.	Declination
22 February	3·4	74	145	0	27	−1·0°
4 March	6·9	60	142	0	22	−1·5°
14 March	11	48	138	0	16	−2·0°
24 March	15	36	134	0	10	−2·25°
3 April	21	27	129	0	08	−2·25°
13 April	28	19	124	0	10	−1·25°
23 April	37	13	119	0	18	−0·0°
3 May	47	7·5	115	0	32	+2·0°
13 May	59	3·1	111	0	51	+4·5°
19–20 May	70	<0·1	109	1	09	+6·5°



The Soviet "automatic interplanetary station" which was launched from a heavy sputnik towards the planet Venus on 12 February, 1961.

angles may lead to unnecessary fuel expenditure and great loss of payload. In order to ensure that the station enters the sphere of the Earth's gravity with the required direction of velocity, a steep angle of velocity may be required at the end of the boost phase in the event of uninterrupted acceleration.

This can be avoided if the boost phase includes the orbiting of a sputnik. The sputnik, carrying the space probe, is placed by the carrier rocket in a circular orbit with minimal losses. The acceleration of the probe, starting from the sputnik, takes place in an almost horizontal direction. Having chosen appropriately the plane of the sputnik's orbit and the point and the time of launching, the escape of the station in the necessary direction can be ensured.

Using a powerful carrier rocket and the method of launching from a sputnik, an automatic station weighing 643·5 km.* was placed in an interplanetary orbit.

By employing sputniks for launching, space missiles can be sent advantageously not over to Venus but also over the most varied space routes.

It has already been stated that the dates of launching and approach to Venus are chosen with a view to ensuring the lowest possible escape velocity. Hence, a series of advantageous launching and approach dates are obtained. Suitable intervals between launching dates range from 1 to 2 months, and are periodically repeated after approximately 19 months. One of these intervals fell at the end of 1960 and the beginning of 1961. This was utilized in the launching on 12 February.

After escape, the station enters an elliptical orbit of periodical motion round the Sun. In connection with this, the length of flight to Venus may vary greatly in different advantageous trajectories. There are trajectories by which the automatic interplanetary station will meet Venus in the first half of its revolution round the Sun, in the second half of the revolution, etc.

For the launching of 12 February a trajectory was selected ensuring that the station would meet Venus in the first half of the revolution. As compared with this, trajectories of other types have certain drawbacks, entailing an increase in the time of flight and a substantially greater possibility of the station's deviation from Venus as a result of mistakes at the end of the boosting phase. Moreover, the distance from the Earth to Venus at the moment of the station's approach to the planet, if these trajectories were chosen, would, as a rule, be much greater than in the present case.

To ensure that the station would move in the immediate vicinity of the planet, it was necessary to guide it on to the calculated trajectory with a great degree of precision. Should there be even very small deviations in the velocity communicated to the station at the end of the boost phase, it would, as a result, pass at a considerable distance from the planet. Velocity mistakes amounting to 1–3 m./sec., with the total speed exceeding 11,000 m/sec., and velocity direction mistakes amounting to 0·1–0·3 degrees could lead to the minimum distance being increased by 100,000 km. The same result would be produced by a mistake of 1 min. in the time of launching.

Deflections of the station's trajectory from Venus may also stem from the approximate nature of our knowledge of the position of Venus. This may lead to mistakes in the calculations of the station's orbit deviations from Venus, mistakes which might even exceed the size of the radius of the planet. The main source of this inaccuracy is the lack of sufficient precision (for this purpose) in the measuring of the astronomical unit (the mean distance between the Earth and the Sun), determining the scale of the solar system.

A more precise notion of the astonomical unit is exceedingly important for space flights.

For the reasons already mentioned, a successful flight to the planet calls for exceedingly accurate measurements of the flight trajectory and for a possibility of minor corrections of the station's motion by means of special devices during the flight to the planet.

With sufficiently precise trajectory measurements on extensive sectors of the station's flight, it will be possible to ascertain the size of the astronomical unit.

Measuring and Control Arrangements

An automatic measuring radio-technical system was specially devised to control the interplanetary station, shape its orbit and carry on two-way communication with it at distances of hundreds of millions of kilometres.

This task confronted Soviet engineers and scientists with several crucial problems of maintaining super-long distance communication and necessarily determining co-ordinates with extreme accuracy and ensuring the reliable functioning of equipment over long periods.

The space probe's trajectory could conventionally be divided into three sections: firstly, the heavy sputnik's

* *One kilogram* = 2·205 *lb.*

orbit; secondly, the space rocket's take-off from the sputnik-carrier; and thirdly, the interplanetary station's coasting towards Venus under the influence of gravitational forces.

The elements of the heavy sputnik's orbit were measured by special ground devices located in the Soviet Union. Information about the functioning of the sputnik's units was received by Soviet ground and ocean stations.

The space rocket was telemetrically fired from the sputnik-carrier.

After the interplanetary station had separated, the set-up for the near-Earth section went into action to conduct orbital and telemetric measurements. Each point in the set-up for the near-Earth section had special radiotechnical relaying and receiving recording devices equipped with parabolic, pencil-beamed, aerials.

When the station was more than 100,000 km. away from the Earth its actual orbit was ascertained by the radiotechnical equipment of the centre for long-distance cosmic radio communication. It is this centre that has been receiving telemetered information from the interplanetary station and has been controlling its instrumentation throughout its flight. By radioed commands the required instruments aboard the interplanetary station are switched on and off, the speed with which information is telemetered is varied, one bank of batteries is switched on and another off, and so on.

For the more remote section of the interplanetary station's orbit all the instruments function in accordance with a special programme determing the length and regularity of communication sessions and the working régimes.

Special narrow-band low-noise receivers are employed to pick up long-distance radio signals. This requires a sufficiently accurate computation of the values of the received and emitted frequencies with allowances made for the Doppler effect. To maintain a steady frequency at the input ends of the narrow-band filters of the receivers aboard the interplanetary station and at the measuring point, an allowance estimated in advance for the Doppler effect is made for the frequencies emitted and received.

At distances measuring tens and hundreds of millions of kilometres, the signal reaching the Earth is extremely weak. At 70 million km., for example, only 10^{-22} W. reach each square metre of the Earth's surface. Aerials covering a large area are required to pick up such small signals, even when supersensitive receivers are employed.

Large aerials have been built at stations of the Distant Space Radio Centre which make it possible to pick up radio signals over tremendous distances.

The aerials can be trained towards any point of the celestial sphere with an accuracy of a few angular minutes. Directional programmes are introduced automatically into the electronic computer controlling the aerials.

All measurements are transmitted via an automatic link to the co-ordinating computer centre where the trajectory measurements are processed, and high-speed electronic computers forecast the station's movement and compute aerial directional programmes. The co-ordinating computer centre exercises overall control of all ground measuring services according to a set programme.

Design of the Station

The automatic interplanetary station is a vehicle equipped with a complex of radio and measuring instruments, an orientation and control system, programme devices and a thermal and power supply control system.

The station is constructed in the form of a pressurized capsule consisting of a cylindrical body with two lids. Inside the capsule there is an instrument frame on which the instruments and banks of chemical batteries are mounted. Outside the capsule are located a part of the transducers for measurements, two banks of solar batteries, the shutters of the thermal control system, and elements of the orientation system.

A block of thermal transducers for studying changes in the optical coefficient of various surfaces in conditions of prolonged stay in interplanetary space at various distances from the Sun is attached to one of the banks of solar batteries. Besides these, four aerials are attached to the capsule on the outside. One of them is a narrow-beam parabolic aerial 2 m. in diameter, which ensures communications with the station at great distances from the Earth and the relaying of a large volume of information within a short period of time.

Two cross aerials mounted on a bank of solar batteries have a wide-beam diagram and are designed for communications at medium distances from the Earth.

A non-directional 2·4-m. rod aerial is designed to transmit information and determine trajectory parameters in the pre-terrestrial phase.

Overall dimensions of the station (without the aerials and the solar batteries) are: length 2035 mm., and diameter 1050 mm.

The station weighs 643·5 kg.

The banks of solar batteries and the parabolic and telescopic aerials, before the separation of the station from the space rocket, are in a folded position and, except for the parabolic aerial, are unfolded immediately upon separation. The latter is unfolded when the station approaches close to Venus.

The design of the station ensures that the initial pressure of gas inside its hermetically sealed body is maintained at about 900 mm. of mercury throughout the entire period of its flight.

The shutters of the thermal regulation system, installed on the cylindrical portion either open or close the radiation surface by turning, thereby correspondingly increasing or decreasing the release of heat generated during the operation of the apparatus. The shutters and the ventilators installed inside the body are controlled with the help of a self-contained programme device with a system of temperature transducers set in places which

may be subjected to extreme overheating or overcooling. This method solves the problem of maintaining normal operational temperatures for the apparatus of the station along the entire trajectory of its flight from the Earth to Venus, as well as during its approach to the Sun at a distance of 110 million km., that is to say, when the intensity of the solar radiation is more than double.

The two banks of solar batteries, by being constantly oriented to the Sun, ensure the continuous recharging of the chemical sources of power supply throughout the entire trajectory of the flight of the automatic interplanetary station, thereby providing current to all the systems and apparatus on board.

The radiotechnical complex of the automatic interplanetary station is called upon to carry out the following tasks:—

Measure the parameters of the movement of the station in relation to the Earth.

Transmit to the Earth the results of the measurements taken by the scientific apparatus of the station.

Transmit to the Earth information on the functioning of the instruments, the pressure and temperature within the station and on the surface of its body.

Receive from the Earth radio commands that control the operation of the apparatus installed in the station.

The apparatus on board the station is controlled through the transmission of commands over a relay line from Earth centres, as well as by self-contained programme devices aboard the interplanetary station.

The system of orientation of the automatic interplanetary station is designed to carry out the following tasks:—

Eliminate the free rotation of the station imparted to it at the moment it was separated from the carrier rocket which was launched from a heavy artificial Earth satellite.

Home the station to the Sun from any position and orient the solar batteries towards the Sun during the entire period of the flight.

Ensure any required turn of the station in space and stabilization of the station in flight.

Ensure in the neighbourhood of Venus the orientation of the narrow beam (parabolic) aerial towards the Earth to secure a higher speed of transmission to the Earth of scientific information and data on the work of the station apparatus.

The automatic interplanetary station is equipped with a complete set of scientific instruments for making physical measurements on the way from the Earth to Venus.

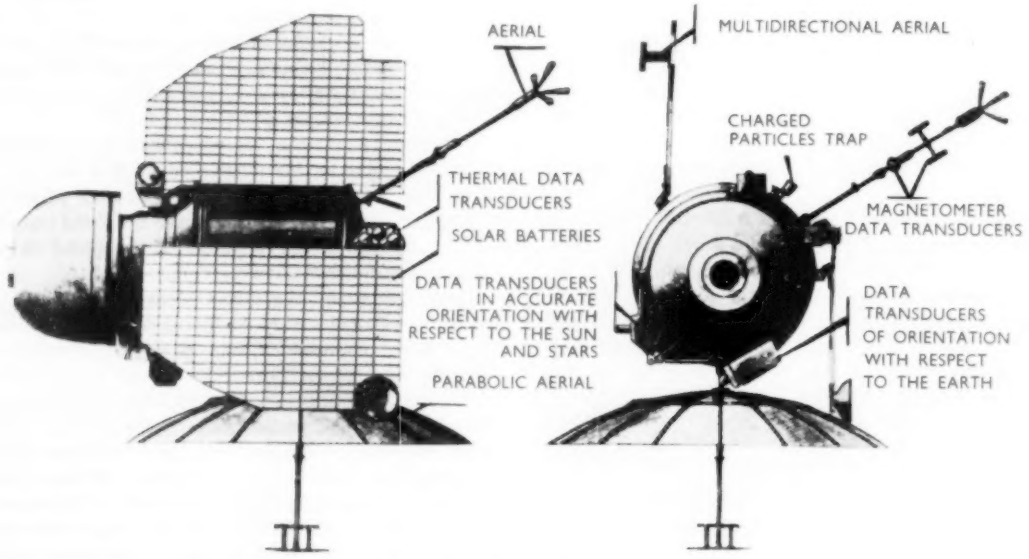
At present the measurements are being carried out by instruments designed for the investigation of outer space at long distances from the planets. Among them are instruments for:—

Measuring cosmic rays.

Measuring the intensity of magnetic fields within a range from several gamma units to several dozen gamma units.

Measuring charged particles of interplanetary gas and corpuscular streams from the Sun.

Registering micro-meteors.


AERIAL
THERMAL DATA TRANSDUCERS
SOLAR BATTERIES
DATA TRANSDUCERS IN ACCURATE ORIENTATION WITH RESPECT TO THE SUN AND STARS
PARABOLIC AERIAL
MULTIDIRECTIONAL AERIAL
CHARGED PARTICLES TRAP
MAGNETOMETER DATA TRANSDUCERS
DATA TRANSDUCERS OF ORIENTATION WITH RESPECT TO THE EARTH

This Russian diagram shows the principal features of the Venus probe.

The automatic interplanetary station is carrying a pennant with the coat of arms of the Union of Soviet Socialist Republics. The pennant is a model of the Earth in the form of a hollow sphere made of a titanium alloy with a diameter of 70 mm. The outer surface of the sphere bears the contours of the continents. The surface of the seas and oceans is given in light blue and that of the continents in gilt.

Inside the spherical pennant there is a medallion with the coat of arms of the U.S.S.R. In the centre of the reverse side of the medallion there is a plan of the solar system giving the orbits of Mercury, Venus, the Earth and Mars; along the edge is the inscription "The Union of Soviet Socialist Republics—1961."

The relative position of the planets is given as at the moment of the approach of the automatic interplanetary station to Venus.

The spherical pennant has been placed in a special protective shell the outer surface of which is shaped into pentagonal elements of stainless steel carrying the coat of arms of the U.S.S.R. and an inscription: "Earth—Venus, 1961."

Radio contact with the Venus-bound automatic interplanetary station could not be established on 27 February, *Tass* announced on 2 March.

"In subsequent days," the announcement said, "as long as the station remains in the zone of direct visibility from Soviet territory, efforts will be made to establish radio contact."

The *Tass* statement continued:—

"As a result of the analysis of trajectorial measurements obtained during several sessions, it has been established that the flight of the automatic interplanetary station to Venus continues along a trajectory close to the one calculated.

"At 12 noon (Moscow time) on 3 March, the station will be 6,683,600 km. (about 4,152,700 miles) from the surface of the Earth at a point with a latitude of 1° 15′ S. and a longitude of 69° 30′ E.

"The speed with which the interplanetary station will be moving away from the Earth at this time will be 4166 m./sec. On the celestial sphere the interplanetary station continues to be midway between the constellations of Pisces and Cetus, almost on the straight between the stars Beta Arietis, Beta Ceti and Alpha Andromedae.

"The automatic interplanetary station's direct ascension by that time will be 0 hr. 21 min. 31 sec. and its declination minus 1 degree 15 min. 3 sec.

"The processing of telemetered information has shown that the station's systems and aggregates functioned normally during the sessions. It was noted that the temperature and pressure inside the station were within the fixed limits and the solar batteries ensured the normal charging of the chemical sources of electricity. The system of solar orientation functioned reliably."

The International Academy of Astronautics

By A. G. HALEY*

The International Astronautical Federation has completed the organization of the International Academy of Astronautics. The Academy is composed of leading scientists and sociologists of the World who are engaged in these fundamental aspects of astronautics: (1) basic science, (2) engineering, and (3) the life sciences, including medicine, law, and other fields dealing with life and survival in space.

Principal powers and functions of the Academy are to: (1) provide advice to the President of the International Astronautical Federation when requested, (2) hold scientific meetings and make scientific studies and reports, (3) publish *Astronautica Acta*, an international technical publication devoted to astronautics, (4) award medals and prizes intended to further the progress of the field, and (5) carry out such other tasks as may be deemed desirable for promoting the advancement of astronautics.

The Academy was formally organized in Stockholm during the XIth Annual Congress of the International Astronautical Federation, 15–20 August, 1960. The first meeting of the Academy took place during the Congress on 16 August, 1960.

Dr. Theodore von Karman, Chairman of the Founding Committee, was designated as Director of the Academy. Professor J. Peres and Dr. Frank J. Malina were designated as Deputy Directors.

The Academy is organized in three sections: (1) Basic Sciences, (2) Engineering Sciences, and (3) Life Sciences. The Chairmen are: Professor A. Ehmert, R. Pesek, and Mr. Florkin, respectively.

The initial membership of the Academy has been determined, and additional members are being elected. It is expected that approximately 150 persons will constitute the full membership.

The members of Section I, in addition to Professor Ehmert, are: Prof. H. O. G. Alfven, Prof. P. Auger, Prof. Nicholas Boneff, Dr. J. C. Davies, Prof. Vladimir

* *General Counsel to the International Astronautical Federation.*

Guth, Prof. Walter S. Hill, Dr. Joseph Kaplan, Prof. A. C. B. Lovell, Prof. M. Nicolet, Prof. J. Peres, Dr. Irene Sanger-Bredt, Dr. Lyman Spitzer, jun., Prof. H. C. Urey, and Dr. J. A. Van Allen.

The members of Section II, under the chairmanship of Professor Pesek, are: Prof. J. Ackeret, Dr. W. von Braun, Prof. L. Broglio, Prof. E. A. Brun, Mr. A. V. Cleaver, Prof. G. A. Crocco, Dr. H. L. Dryden, Prof. A. Eula, Dr. Th. von Karman, Prof. J. M. J. Kooy, Prof. L. Malavard, Dr. F. J. Malina, Dr. H. Oberth, Dr. W. H. Pickering, Dr. E. Sanger, Dr. L. R. Shepherd, and Ing. Teofilo M. Tabanera.

The members of Section III, of which Professor Florkin is Chairman, are: Prof. R. K. Andjus, Gen. P. M. Bergeret, Prof. J. C. Cooper, Dr. E. Evrard, Brig. Gen. D. Flickinger, Prof. W. H. Franks, Mr. A. G. Haley, Prof. J. Lederberg, Dr. W. Randolph Lovelace, II, Prof. Alex Meyer, and Dr. H. Strughold.

The Academy has received generous donations of funds, headquarters space and other assistance. The Daniel and Florence Guggenheim Foundation of New York has approved a grant of a total of $75,000 for the work of the Academy. Headquarters office space in Paris has been furnished free of charge for 3 years through the efforts of General Paul Bergeron. The offices are located at the Caisse Nationale des Marches de l'Etat, 12 rue de Gramont, Paris 2e.

The programme of the Academy for the future was described by Dr. von Karman at the first meeting, as follows:—

(*a*) *Advice to the President of the I.A.F. upon request.* One of the principal functions of the Academy is to provide advice to the President of the Federation whenever so requested. The Academy stands ready to give such advice to the best of its ability.

(*b*) *Astronautica Acta Journal.* The editorial management of the Acta was reorganized under my direction during the first part of 1960. A number of the initial members of the Academy are serving either in an editorial capacity or on the Editorial Advisory Board of the Journal. The Journal is intended to serve the rapidly growing community of scientists and engineers who are devoting themselves to any of the many aspects of astronautics as a publication having a widely international character. Furthermore, it is planned to co-operate closely with the publishers of several national journals. It is the intention of the editors of the *Acta* to supplement rather than compete with other journals in this field. Special attention will be given to articles of the type that will serve as valued corner-stones of the edifice of astronautical literature. It is also planned to publish periodically survey papers in the selected fields of the fundamental, engineering, and life sciences bearing on astronautics. Consideration is being given to the desirability of adding a section for short reports submitted by members of the Academy, and for letters dealing with matters published in the Journal. A short section giving Academy news might also be usefully added.

(*c*) *Scientific Meetings.* No change is contemplated as far as the Congress of the Federation is concerned. It is proposed, however, that smaller scientific meetings of the symposium type held in conjunction with the Congress be the responsibility of the Academy, at least as far as the technical programme of these meetings are concerned. Meetings initiated by the Academy, whether held in conjunction with the Congress or at other times and places would, or course, be the responsibility of the Academy. A proposal to UNESCO for a subvention for 1961–62 includes a meeting of a preliminary study group to be organized by the Academy for the purpose of determining the desirability and feasibility of holding a symposium in 1963 on the problems of "Man in Space."

(*d*) *Multi-lingual Handbook of Terms used in Space Research.* The Federation has for some time given its attention to the question of the definition in various languages of terms used in the field of extra-terrestrial space exploration. The Federation has requested financial assistance from UNESCO for the completion of this work in 1961–62.

(*e*) *Consideration of the Establishment of an Academy Award and Fellowships.* During my discussions with the Daniel and Florence Guggenheim Foundation I mentioned that the Academy may wish to establish a medal or award of the highest international significance in the field of astronautics, possibly to be named after a leader or family which has made contributions of outstanding importance to the development of this field. The Academy may also wish to establish a postgraduate fellowship programme and to direct its efforts toward finding funds for such a programme. Subject to the approval of the Assembly of the Academy, I would recommend the setting up of an Academy Committee to study these questions and to present a report to the first regular meeting of the Academy in 1961.

The Academy has organized several working committees to carry on special projects. These include Finance, Publications, Academy Award and Fellowship, and Lunar International Laboratory Committees.

The Academy is also active in allied endeavours. At present the Director is continuing discussions with UNESCO with regard to a meeting in 1961 or 1962 which would consider the feasibility of holding a symposium in 1963 on the scientific and technical problems of "Man in Space." A Committee has been appointed to function in a Joint Commission of the Academy and the International Institute of Space Law on Technical Aspects of Space Law.

Election of New Members

Niels Bohr, the world-famous Danish physicist, has recently been elected the first Honorary Member of the International Academy of Astronautics. The following new members have also been elected.

Basic Sciences Section

Prof. Julius Bartels.
Prof. David R. Bates.
Prof. L. Biermann.
Prof. Sydney Chapman.
Dr. Herbert Friedman.
Prof. Leo Goldberg.
Dr. Homer E. Newell.
Prof. Fred L. Whipple.

Engineering Sciences Section

Dr. Adolf Busemann.
Prof. Elie Carafoli.
Prof. Luigi Crocco.
Eng. Krafft A. Ehricke.
Dr. Howard S. Seifert.
Prof. Antonio Ferri.
Prof. Arthur R. Kantrowitz.
Dr. Michael J. Lighthill.
Prof. Maurice Roy.
Dr. Ernst Stuhlinger.
Dr. Martin Summerfield.

Life Sciences Section

Dr. Robert Grandpierre.
Prof. U. S. von Euler.
Dr. Ashton Graybiel.
Prof. Tomaso Lomonaco.
Prof. Rodolf Margaria.
Dr. Hermann J. Schaefer.
Prof. Gustav Schubert.
Col. John P. Stapp.
Air Comm. W. K. Stewart.
Dr. P. M. Van Wulften Palthe.
Sir Harold E. Whittingham.

The Academy now has a total membership of 76, coming from 18 countries. It will next meet in October, 1961, in conjunction with the Washington I.A.F. Congress. During this meeting, the first Daniel and Florence Guggenheim International Astronautics Award will be presented. This international prize of £300 is given annually to any individual who has made outstanding contributions to astronautics, during the five preceding years.

The Academy will also review the work of the following Committees: Publications, Awards and Fellowships, Lunar International Laboratory, and the Joint Commission of the Academy and the International Institute of Space Law on Technical Aspects of Space Law.

Astronautics in Japan

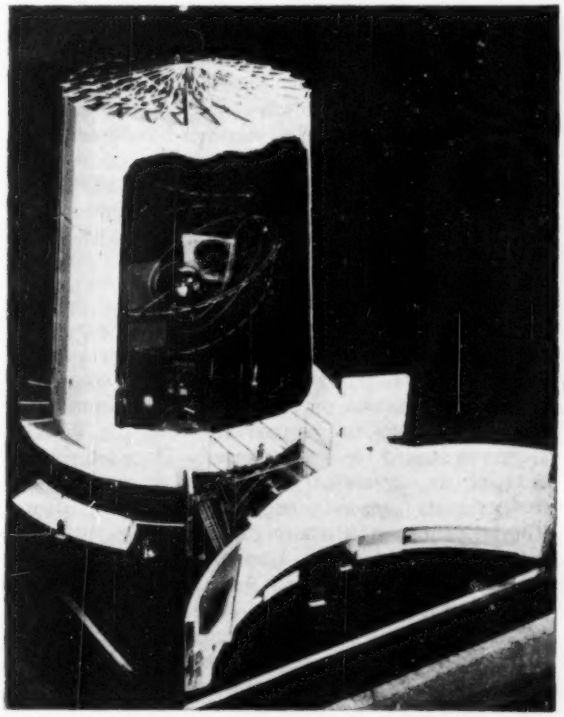
The third (1961) International Symposium on Rockets and Astronautics will be held in Tokyo from 28 August to 1 September.

The Symposium is being organized by the Japanese Rocket Society, which was formed in 1957 and which now publishes *Rocket News* (monthly in Japanese) and the *J.R.S. Journal* (quarterly in English). The J.R.S. also holds an annual "Aero-space Exhibition" in co-operation with the Japanese Aeronautical Association, besides rendering financial assistance to experimental effort. For example, the J.R.S. helped financially in the development of the Rockoon system in 1956–57.

The President of the J.R.S. is Sukenori Wamamoto, Yomiuru Newspaper Building, 1–3, Ginza-Nishi, Chuo-ku, Tokyo.

Another Problem Solved

"Just announced by Aeroneurotics Inc., a small but aggressive new company, is a method of feeding space pilots in weightless zero *g* conditions. An extract of snail juice is added to concentrated food pastes to make them crawl down the pilot's throat under their own power."—"Roger Bacon" in *Flight* (27 January, p. 123).



Dominating the Soviet Trade and Industry Exhibition at Earls Court from 7 to 29 July will be this massive centre-piece, devoted to Russian achievements in the conquest of space.

Minitrack in Britain

In January, the Editor was one of a number of journalists who visited the new Minitrack Station at Winkfield at the special invitation of the Department of Scientific and Industrial Research. This article outlines the station's principal features.

Our cover picture this month depicts a control console which is part of the Minitrack Station recently established at Winkfield in Berkshire. The facility is one of a network of fourteen such stations distributed throughout the world for the purposes of tracking artificial satellites and recording measurements telemetered from their research instruments.

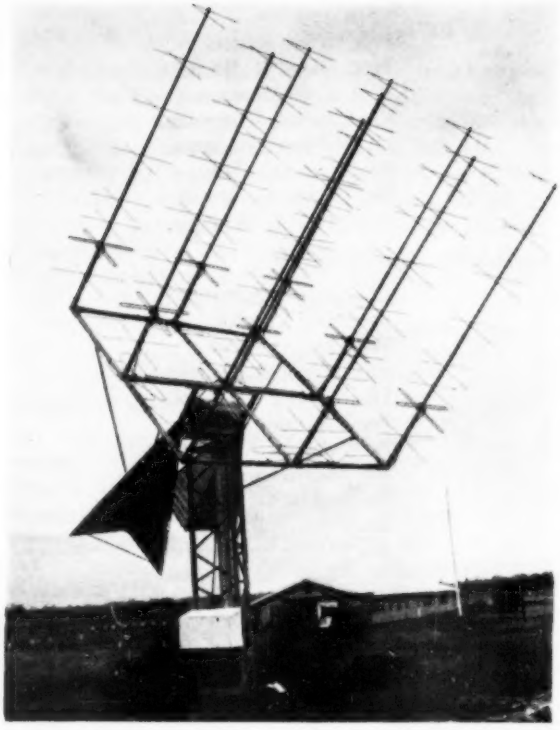
The equipment is supplied on loan by the National Aeronautics and Space Administration which is the United States Government department responsible for carrying out the non-military aspects of space research. Staff of the Radio Research Station of D.S.I.R. operate the installation. Until recently there were ten Minitrack Stations, mainly in North and South America but including one in South Africa and another at Woomera in Australia. Originally set up to track satellites having orbits at comparatively small inclinations to the equator, this network is sited in low latitudes.

The Winkfield installation is one of four additional stations to provide cover on satellites having orbits with higher inclination angles. Information derived from the equipment—tracking and telemetered data from the satellites—is available for use by the Radio Research Station and in the general British space research effort.

Teleprinter Network

A teleprinter circuit to the Goddary Space Flight Centre of N.A.S.A. is used to convey summarized results from each satellite transit observed at Winkfield. In the reverse direction up to date orbital information on all relevant satellites is provided, and the Winkfield station is alerted for new launches. Data are provided enabling the directional aerials used in receiving telemetry signals from the satellites to be correctly oriented. The teleprinter system also provides a link with other research centres in the United States, including the Smithsonian Astrophysical Observatory which analyses the optical observations on satellites obtained from precision cameras set up in various parts of the world. This facility will prove of particular value to the Slough headquarters of the Radio Research Station, which is also connected to the teleprinter circuit.

The Winkfield installation and its communication network will be of considerable value to the research



A steerable telemetry aerial used for receiving the results of experiments in scientific satellites.

All photographs Central Office of Information, Crown Copyright Reserved

effort in the two countries, particularly when British experiments are flown in S-51 satellites launched from Scout vehicles. Another example of the use of the Minitrack Station will be the reception of the telemetered data from apparatus flown in satellites to investigate the upper portion of the ionosphere. The Radio Research Station is to collaborate with American and Canadian scientists in two "topside sounder" experiments of this kind by receiving the data at Winkfield and at its outstations at Singapore and in the Falkland Islands. The information obtained in this way about the upper side of the ionosphere will be complementary to that about the lower side which the Radio Research Station obtains from ground experiments.

The tracking facility at Winkfield is of high precision and uses the interferometer principle to determine the direction of the satellite. The phase difference between radio signals received on aerials spaced apart at accurately known positions is measured: the phase difference represents the difference in time taken by the waves to reach the two aerials. By making simultaneous measurements on aerials set up on a N.S. (North-South) line and others on an E.W. (East-West) line the phase differences

can be converted to give the angle in space of the satellite. Highest accuracy of angular measurement is given for a satellite immediately above the system; in this situation a precision of a few seconds of arc might be expected ideally, but in practice this is likely to be degraded to the order of a minute of arc corresponding to a movement of only a few hundred yards for a satellite at a height of, say, 400 miles.

Photographic Check

From time to time it is necessary to check the accuracy of the system and for this purpose a specially designed camera is mounted at its centre. An aircraft carrying a flashing light, controlled from Winkfield, and a transmitter is flown over the system on a clear night and photographed. The true direction of the aircraft at any given instant is found from the photograph, which shows the position of the aircraft against the star background, and serves as references against which to compare the simultaneous radio measurements of direction.

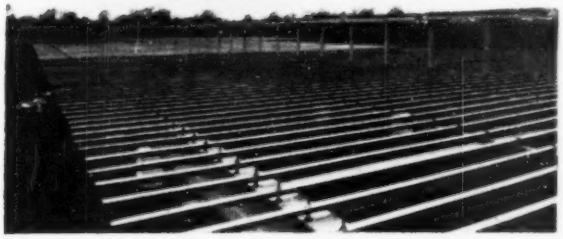
It is necessary to know the time as accurately as possible when each measurement of direction is made and this is achieved by means of a crystal clock. This provides timing marks—or "read-out" times—at 1-sec. intervals or shorter to an accuracy of the order of a thousandth of a second. They appear on the paper charts on which the phase differences between the various interferometer aerials are recorded.

Receiving Equipment

The equipment used for receiving experimental data telemetered from the satellite comprises remotely controlled beamed aerials—one receiving on 108 Mc/s. and another on 136–137 Mc/s.—a receiver and a magnetic tape-recorder. The eight channels of the tape-recorder are used for various functions depending on the particular satellite under observation. Generally, however, they record the signal strength, timing pulses derived from the crystal clock and signals of accurately known frequency (used for monitoring the speed of the tape) together with the essential telemetry information. A transmitter is incorporated in the installation and serves to activate a receiver carried in the satellite; this facility can be used, for example, to cause experimental data recorded on a tape-recorder in the satellite to play back the information by radio to Winkfield where it can be re-recorded.

Main building at the Minitrack Station at Winkfield, Berkshire in which the electronic equipment is housed.

The Minitrack system has been erected by the Ministry of Works on farmland, parts of which have been rented for some years by the Radio Research Station for other research work. The Ordnance Survey carried out the detailed survey work including the provision of precisely defined markers over which the aerials have been erected. Throughout, close co-operation and liaison has been necessary with the N.A.S.A. which has provided teams to supervise the erection and testing of the aerials, the installation and testing of the equipment in the main building, and finally in the calibration of the system. The calibrating aircraft was provided and flown by staff of the Royal Aircraft Establishment who were also responsible for the installation of the radio equipment in the aircraft. The teleprinter circuit to Goddard Space Flight Centre is provided by N.A.S.A. and all arrangements for its installation were made by the General Post Office. Work on the site started at the beginning of 1960 and first telemetry observations on 108 Mc/s. were made at the time Explorer 8 was launched on 3 November, last year. The initial calibration of the interferometer was carried out early in December, 1960, and the system is ready for operation as soon as satellites carrying 136–137 Mc/s. transmitters are launched.



Close-up of one of the "fine" aerials of the Minitrack interferometer system.

Entente Spatiale

The first major move into space by British industry was revealed recently when the Hawker Siddeley Group made public a joint Anglo-French industrial study of aerospace potential. The feasibility study, jointly conducted by Hawker Siddeley and S.E.R.E.B. (Societe pour l'Étude et la Realization d'Engines Ballistiques) was issued simultaneously in London and in Paris and listed three main projects for government consideration.

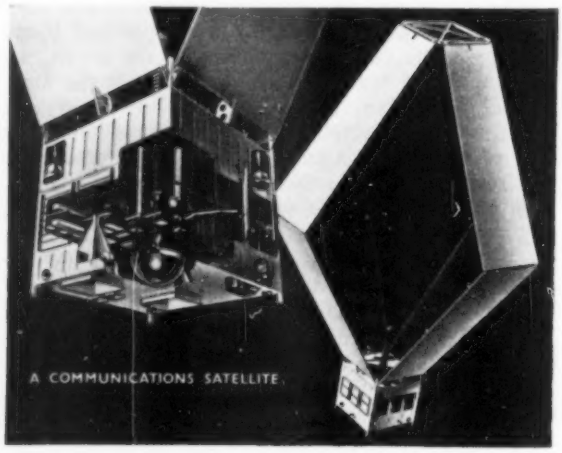
(1) Communications satellites.
(2) Navigation satellites.
(3) Anti-orbital missiles.

The study disclosed that Hawker Siddeley and S.E.R.E.B. have been working together for many months as a Franco-British Initiative Group for an industrial study of aerospace potential in Europe.

S.E.R.E.B. represents an association of the most powerful aircraft and missile interests in France and is controlled by the French Government. Hawker Siddeley Aviation controls seven British aviation and missile companies, the largest single group in the Commonwealth.

Although the Initiative Group has been founded on Franco-British collaboration, the door has been left open for aero-space industries in other countries. Commenting on the study, Sir Roy Dobson, Managing Director of Hawker Siddeley Group, said that the joint evaluation, industry to industry, was an essential first step to any government sponsored aerospace programme involving Europe and the Commonwealth.

He emphasised that the design projects under study were not allied to any particular rocket combination, but from an industrial point of view an initial evaluation must be made of projects within the scope of Western European capability. The studies have already been submitted to both the British and the French Governments.



Artist's impression of the proposed Hawker-Siddeley active communication satellite.

Hawker-Siddeley Aviation, Ltd.

The Hawker Siddeley/S.E.R.E.B. studies on communication satellites include one British and one French design. As an example, four or five of one of the proposed communications satellites in an appropriate orbit would provide 24-hr. a day coverage for a London/New York link. This system offers a real alternative to conventional cable communications and could also give a service to isolated regions of the Earth.

The navigation satellites are, in effect, man-made stars for ship and aeroplane navigation through precise celestial fixes.

The third design submission is an anti-orbital defence weapon which illustrates current trends in military thinking.

In addition to the communication and navigation satellites and the anti-orbital missile, the Hawker Siddeley/S.E.R.E.B. report devotes a section to even more advanced aerospace studies. This covers such fields as the study of new propulsion concepts, the evaluation of material properties in a space environment, the design of light-weight structures and the miniaturization of electronic equipment.

The development of such new techniques based on this research will ultimately benefit industry in general and is of much importance in these times of economic competition, the companies point out.

Leading the Hawker Siddeley team in this study are:

Stuart Davies, Technical Director of Hawker Siddeley Aviation.

James Floyd, Chief Engineer, Advanced Projects Group, Hawker Siddeley Aviation.

Michael Golovine, Managing Director of A.T.S. Co. Ltd.

Dr. William Frank Hilton, Head of Astronautics Section of the Advanced Projects Group, Hawker Siddeley Aviation.

H. R. Watson, Aerospace Director of Armstrong Whitworth Aircraft.

Both Mr. Golovine and Dr. Hilton are Members of the B.I.S. Council.

The S.E.R.E.B. Company was set up by the French Government in 1959 to act as systems managers for all ballistic weapon development to be undertaken in France or in association with other countries. Shares in the Company are held by Nord-Aviation, Sud-Aviation, S.N.E.C.M.A., Office National D'Études et de Recherches Aeronautiques, General Aeronautique Marcel Dassault, M.A.T.R.A. and S.E.P.R.

A British Space Consortium

The British Space Development Company Limited has been formed in order to bring together a representative cross-section of that part of industry which is interested in the development exploitation of space for commercial purposes and which believes that the use of space will, in the next two decades, become a major key to the continued prosperity of the U.K. and Commonwealth, politically and industrially. It is considered that a successful and economic entry into the new medium of space demands a unified effort on the part of British industry.

Briefly, the initial aims of the B.S.D.C. are as follows:—

(*a*) To provide an organization to discuss with the Government and co-operate in any proposals that the Government may make in regard to a U.K. and Commonwealth space programme, which is either independent of European participation or which includes European participation.

(*b*) To provide the Government with an indication of the faith that British industry has in the exploitation of space and to show its readiness to play its part and to take its share of the risks as well as its share of the future benefits.

(*c*) To offer the Government an industrial body broadly based to act as an authority or agency to conduct research and development and to implement and operate a space programme and to consider and develop all the possible areas of exploitation of space.

(*d*) To provide those industries concerned with an organization to negotiate with other countries or foreign industrial organizations or consortia any matters concerning the commercial uses of space which are likely to have global implications, *i.e.*, communications, broadcasting, television, meteorological forecasting and navigational aids.

(*e*) To provide the greatest economy in the use of the limited number of technical personnel available in the country, particularly in the field of astrophysics and astronautical engineering and to ensure that duplication of effort, which has been so prevalent in the U.S.A. and which has contributed to wasteful use of resources, is avoided in the U.K.

(*f*) To encourage the provision of and to provide directly, in due course, facilities for the training of an adequate number of technical personnel in all those sciences associated with space research and the exploitation of space.

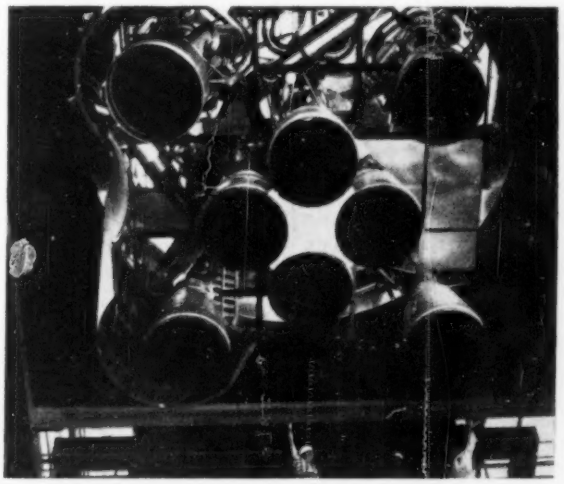
(*g*) To preserve for British industry a place in Space and a proper share of the national and international benefits deriving from the development and use of space.

It is possible that the Company may develop into an international company, particularly as no enterprise in the world has as yet been envisaged where such a wide cross-section of industry has come together to pool its resources, know-how and effort in order to compete in this demanding, expensive but ultimately most lucrative new technical field with its limitless possibilities.

The British Space Development Company now being formed will have an initial capital of £20,000. The following companies will be the initial participants:—

Associated Electrical Industries.
Associated Television.
British Insulated Callender's Cables.
Bristol Siddeley.
Decca Radar.
Hawker Siddeley Aviation.
Pye.
The Rank Organization.
Rolls-Royce.

It is anticipated that other interested companies will also take part.



Engine cluster of the Saturn C–1 booster. Four inboard engines are rigidly attached and canted at an angle of 3 deg. to the long axis of the booster. Outboard engines are canted at an angle of 6 deg. and are gimbal-mounted with 10 deg. freedom of movement for thrust vector control. Each Rocketdyne H–1 engine develops a thrust of 188,000 lb.

North American Rocketdyne

Russia's Space Stamps

By DONALD MALCOLM, F.R.A.S.

Since the launching of Sputnik I on 4 October, 1957, business in stamps dealing with various aspects of spaceflight has been booming. Discounting I.G.Y. issues, which I dealt with in a previous issue of this magazine, the bulk of "space stamps" has been put out by countries in the Communist world.

The Russians themselves, of course, have not been slow to exploit and extend the immense propaganda value of their achievements through philately. Many stamps, as well as special cachets and postcards, have reiterated Soviet claims to be supreme in the field of space technology.

To a large extent, the general public was prepared for the advent of artificial satellites by ex-President Ei enhower's announcement in 1955 about the part they would play in America's contribution to the International Geophysical Year. But no writer ever gave a greater twist to a story than the Russians gave to history by launching their 184-lb. Sputnik I, which surprised all but the Soviet scientists and engineers concerned. It compared with the 21½ lb. of the celebrated Vanguard satellite which the Americans had so skillfully miniaturized for launching by an equally minimum-sized three-stage rocket.

A month after Russia's initial space triumph—5 November to be exact—two commemorative stamps appeared.* Both vertical, they had the same design and value, 40 kopecks. The satellite is shown orbiting the globe and the wording indicates that it was the first artificial satellite of the Earth.

One issue of the stamp is blue, while the other is deep slate blue and pale blue. A second anniversary cachet shows Sputnik I over Moscow Planetarium.

Three days after the satellite went up, a beautiful 40 k. stamp—the colours were sepia, bistre-brown, deep blue and blue—was issued; this showed Soviet rocket pioneer, Zsiolkovsky, flanked by the planet Saturn, a rocket and a satellite.

A small quantity of this stamp was overprinted, "4 x 57 1st Artificial Satellite of the World," and issued on 28 November, 1957.

People had hardly recovered from the surprise of the novelty beeping overhead when the Soviets announced the successful launching of Sputnik II, weighing 1120 lb., with the now-immortal dog Laika aboard. That was on 3 November, 1957.

* *Actually, the very first Sputnik stamp was a 10 pf. value from East Germany (see* Spaceflight, *Vol. II, No. 8, pp. 235–36).*

Laika, first canine astronaut, with representations of Sputniks I, II, and III, on coloured postcard.

Photo: Alec Rodgers

In scientific circles, thinking had to be re-orientated. Minds had been bemused so much by the belief that the first satellite would be an American one of 21½ lb. that Russia's outsize Sputnik took a bit of believing. The launching rocket then being developed for Vanguard had an all-up weight of 22,000 lb., meaning that almost 1000 lb. of propellents were required to lift 1 lb. of satellite into orbit. The estimated weight of Sputnik II's launching vehicle was 80 tons, some eight times that of Vanguard's.

Little or no detailed information was forthcoming from behind the "Curtain" on the score of ballistic hardware presumably because the rockets used had primarily military associations.

On 30 December, 1957, four Sputnik II stamps were put on sale. The design common to them all was the Allegory of Science and the symbolic trial of a satellite. The values were 20 k. (rose-red and black), 40 k. (emerald and black), 60 k. (orange-brown and black) and 1 rouble (light-blue and black).

No stamp was issued for Laika by Russia, but a special coloured postcard showing the dog and the three Sputniks eventually appeared.

On 31 January, 1958, America retrieved some of her waning prestige with the launching of Explorer I, but on 15 May, when the 2925-lb. Sputnik III was placed in orbit, the spotlight was again strongly focussed upon the Russians.

Sputnik III was commemorated by a 40 k. stamp and label, *se-tenant* (issued 16 July, 1958), which gave details of the satellite's date of launching, weight, orbit, and so on. Special cachets were used to record 3000, then 10,000, revolutions. A Christmas card, showing the cone-shaped Sputnik over the Moscow State University, was also issued.

On 2 January, 1959, came news that a Russian rocket was heading for the Moon. Lunik I passed within 4000 miles of the lunar surface and entered a solar orbit sometime between the 7 and 8 of January.

Lunik I may have been intended to hit the Moon. An error of one degree or so in the angle of launching would account for the 4000 mile "miss distance."

The weight of the final stage of the launching rocket was given by the Russians as 3245 lb. The probe itself, weighing 796 lb., will stay in orbit indefinitely as an artificial planet.

Russian philatelists actively participate with the Ministry of Communications in the design of Soviet stamps. Perhaps this explains the considerable lapse before the appearance of the two Lunik I 40 k. stamps on the 13 April, 1959. One, blue and light blue, shows the preliminary route of the rocket after launching; the other depicts the rocket's trajectory, and is coloured red-brown and pink.

A multi-coloured 1 r. stamp issued on the 3 January in commemoration of the 21st Communist Party Congress depicts a large rocket with the inevitable three Sputniks, turning up like the three witches. The rocket *might* be that of Lunik I. About the stamp itself, a philatelic writer stated in an article on I.G.Y. stamps that it celebrated International Geophysical Co-operation, an extention of I.G.Y!

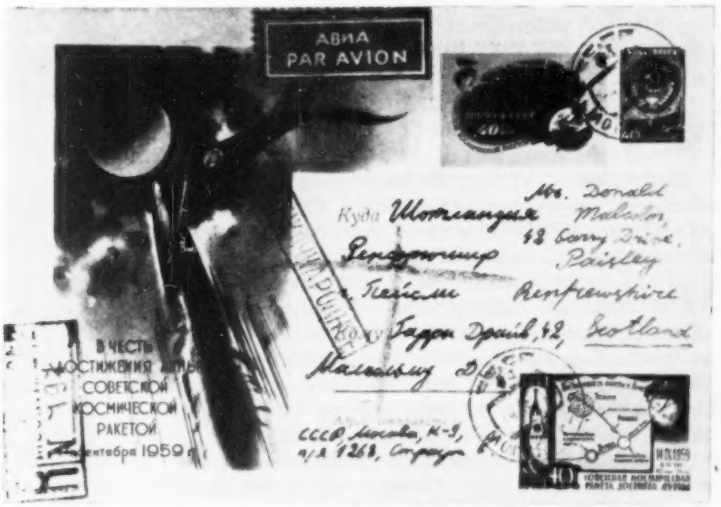
A special cachet issued at the time shows the rocket leaving the Earth, passing the crescent Moon, and entering a solar orbit. The appropriate dates are given. Round the cachet are the words, "First Artificial Planet of the Sun." A 21st C.P.C. cachet has Lunik I, Sputniks I, II and III, and the atomic ice-breaker, *Lenin*.

The next space success, in the shape of Lunik II, came on the 12 September, 1959, with the announcement of the launching of a rocket with the avowed purpose of hitting the Moon. This it duly did, on the 14th. An artificial sodium cloud, ejected *en route*, was successfully photographed by a number of Soviet observatories. Special, indestructible, pennants inscribed, "The Union of Soviet Socialist Republics, September, 1959," were carried in the impacting instrument package. These will make good souvenirs for the eventual lunar explorers.

Two Lunik II stamps, each 40 k. in value, came out on 1 November. The first is violet-blue, red, yellow, and light blue and shows a symbolic rocket trajectory from Earth to the Moon, which is complete with hammer and sickle. The second shows the Kremlin and a rocket path leading to the beflagged Moon. This stamp, blue, grey-green, light mauve and red, gives the time of impact as 0·2 min., 24 sec. A first anniversary cachet has a representation of the pennant crash-landed on the surface as its principle design.

One of mankind's most cherished dreams had been to see the hidden side of the Moon, and many were the romantic and scientific notions of what lay there.

An initial glimpse was obtained when Russia launched Lunik III, also known as the Automatic Interplanetary



Cover commemorating the launching of Lunik II.
Photo: Alec Rodgers

Four issues commemorating "International Geophysical Co-operation."
Photo: Alec Rodgers

Station, on the 4 October, 1959. From a distance of about 35,000 miles, and against the glare of a full Moon, photographs were taken of the hidden side. Photographs, processed in the satellite, were transmitted to Earth on the receipt of command signals.

Eight days after the launching, a 40 k. violet stamp was issued. It includes a great deal of technical information but is one of the less inspired designs, the main feature being the orbit of the station (see diagram, *Spaceflight*, Vol. II, 5, p. 132).

Two other stamps were subsequently issued. These do much more credit to the achievement. The 40 k., dark blue and yellow-green, shows the station above the lunar surface; the 60 k. depicts a "green cheese" Moon on a dark blue, star-flecked background. The salient features are marked on the disc.

A special first anniversary cachet was issued. The station is seen above part of the Moon.

At the time of writing, the latest space stamps to be issued are the pair commemorating the launching of Sputnik V—popularly termed "Arknik," of course—with the dogs Belka and Strelka as its principal passengers. This was on 19 August, 1960. The stamps, 40 k. and 1 r. in value, are really striking. The design for both shows the Kremlin in the centre, with part of the globe in the back-ground. Above it is a "Flash Gordon" rocket, complete with exhaust trial, transmitting pictures to an aerial array on the right. On the left, Belka and Strelka appear framed in a television screen.

A postcard featuring the dogs was also available.

In the philatelic field, America can claim one distinction. A cover, bearing a stamp with the Stars and Stripes on it, was carried in a successfully recovered Discovery capsule. This can be claimed as the first space cover.

The covers still to come—first man in orbit, first man on the Moon, and many more, should be worth seeing.

The following list may serve as a guide to any readers who may be interested in starting a collection of Russian stamps of technical interest.

Subject	*Value*	*Date of Issue*	*Details*
Zsiolkovsky ..	40 k.	7 Oct., 1957	—
Sputnik I ..	40 k.	5 Nov., 1957	(2 shades)
(Special 2nd Ann. Cachet: Sputnik over Moscow Planetarium)			
*Sihote-Alinj Meteor ..	40 k.	20 Nov., 1957	10th Ann.
Zsiolkovsky ..	40 k.	28 Nov., 1957	Overprint
Sputnik II ..	20 k.	30 Dec., 1957	—
	40 k.	30 Dec., 1957	—
	60 k.	30 Dec., 1957	—
	1 r.	30 Dec., 1957	—
Sputnik III ..	40 k.	16 July, 1958	—
(2 Special Cachets: 3000 and 10,000 revolutions)			
*Tunguz Meteor	40 k.	12 Aug., 1948	L.A. Kulik: 50th Ann.
*10th I.A.U. ..	40 k.	16 Aug., 1958	Observatory,
	60 k.	15 Aug., 1958	Moscow Univer-
	1 r.	12 Aug., 1958	sity, Telescope
(Special Cachet: University)			
*All Union Ind. Exhibition ..	40 k.	31 Dec., 1958	Atomic icebreaker *Lenin*
	60 k.	7 Jan., 1959	TE.3 Diesel
21st C.P.C. ..	1 r.	3 Jan., 1959	—
(Special Cachet: Path of Lunik I)			
*A.S. Popov Cent. ..	40 k.	13 Mar., 1959	Ship: Men on Ice Flow
	60 k.	13 Mar., 1959	Radio Beacon Radiating "Peace"

Lunik ..	40 k.	13 Apr., 1959	—	
	40 k.	13 Apr., 1959	—	
*International Geophysical Co-op. ..	10 k.	18 Aug., 1959	Surveyor	
	25 k.	20 Oct., 1959	*Vitjaz* (mapping),	
	40 k.	18 Aug., 1959	Antarctic Base,	
	1 r.	16 Sept., 1959	Observatory and Rocket	
Lunik III ..	40 k.	12 Oct., 1959	—	
Lunik II ..	40 k.	1 Nov., 1959	—	
	40 k.	1 Nov., 1959	—	
Lunik III ..	40 k.	— 1959	—	
	60 k.	— 1959	—	
Sputnik V ..	40 k.	— 1960	—	
	1 r.	— 1960	—	

* *Various technical issues.*

Man in Orbit

A new Soviet 10-kopeck stamp in honour of the World's first manned space flight went into circulation on 13 April, the day after the historic orbital flight by Major Gagarin. It depicts the launching rocket against a blue sky, under the inscription "Soviet Man In Space." On the left is a picture of the astronaut clad in his pressure suit and below, on the right, the Kremlin is shown in silhouette. The date 12.4.61 is inscribed on the stamp. Designed by Joseph Levin, it is printed in three colours by the mezzotint method.

First static test of a 15,000 lb. thrust segmented solid-propellent rocket motor at the Development Centre of United Technology Corporation, Dec. 1960.

United Technology Corporation

Echo and Solar Storms

Scientists of N.A.S.A.'s Goddard Space Flight Centre have reported that the severe solar storm of 12 November, 1960, produced a substantial change in the orbit of Echo I, the 100 ft. balloon satellite.

The calculation which revealed the effect of the storm on the satellite was carried out by Dr. Robert Jastrow, Chief of Goddard's Theoretical Division, and Robert Bryant, also of the Theoretical Division.

Their study of the orbit of Echo I revealed that on 12 November, at approximately the time of the solar storm, the atmospheric drag acting on the satellite increased by about a factor of two, extending the orbital period 2 sec./day. It remained at this high value for several days before returning to its previous level. The most likely cause of the increase in the drag is an increase in the average density of the air through which the satellite moves, produced when particles and radiation from the solar flares strike the atmosphere and heat it.

The heating results in a slight upward expansion of the atmosphere at lower levels, and a great increase in the density of the very thin air at the high altitudes of 900–1000 miles in which Echo I travels around the Earth.

Echo I, a passive communications satellite launched by N.A.S.A. 12 August, 1960, went into an almost circular orbit approximately 1000 miles above the Earth. Last December its apogee was 1334 miles, perigee 619 miles and period, 117·428 min.

Previously, scientists at the Smithsonian Astrophysics Observatory in Cambridge, Massachusetts, and in Germany and England, had discovered that the whole upper atmosphere rises and falls, or "breathes," in response to the general level of storminess on the surface of the Sun. However, the response of satellites to a specific solar flare has been detected only once before, in 1959, in the case of Sputnik III. It has not been detected in the orbit of Vanguard I.

Echo I passes through the outer Van Allen belt, as did Sputnik III. The intensity of the outer belt increases as much as a thousand-fold after solar flares, according to measurements obtained with Explorer VI and VII. Vanguard I does not go through the outer belt because it is confined to low latitudes, less than 33°. It is possible that this fact may explain why the solar storms have influenced the drag on Sputnik III and Echo I, but not on Vanguard I. Jastrow and Bryant believe that the detection of the solar storm effect on the Echo I orbit may provide a clue to the actual mechanism by which solar particles and radiation heat the atmosphere. This is one of the basic problems facing physicists in their effort to understand the influence of solar weather on the Earth.

"*Solar Weather*"

The solar storm of 12 November was the most severe one that has occurred since the great flare on 23 February, 1956. It consisted of two giant flares on the surface of the Sun and several smaller eruptions, all within a period of a few days.

The surface of the Sun boils and churns in times of unusual solar activity, and produces disturbances which are analogous to the occurrence of bad weather on the Earth. Scientists have begun to talk of this activity as "solar weather." Occasionally the storms on the Sun produce the great eruptions known as flares, which spray charged particles and X-rays through the solar system. When the particles and radiation reach the Earth they have a number of serious effects:

(1) they increase the number of charged particles in the atmosphere, which weaken and distort the transmission of radio waves through the ionosphere and generally play havoc with international radio communications; during the 12 November storm, international radio communications were blacked out for 2 days;

(2) they produce magnetic storms, or irregular fluctuations of the compass needle;

(3) they produce brilliant auroral displays, or Northern Lights; and

(4) they empty and fill the Van Allen belts with charged particles; the way in which this happens is not yet entirely understood, and currently constitutes one of the major research goals of the N.A.S.A. space science programme.

The whole question of the way in which solar weather creates these disturbances on the Earth is a new chapter in science, which first came to the centre of attention only a few years ago in the analysis of I.G.Y. findings. It is one of the most interesting problems for space scientists.

Meteorological Rocket Exhibits

In co-operation with the U.S. Navy, the British Interplanetary Society are able to make available for loan to schools a rocket research exhibit which portrays the use low-cost rockets for upper atmosphere research.

The exhibit consists of seven large explanatory panels, five meteorological rockets suitably mounted on stands, a few component parts, and one nose-cone recovered from an altitude of more than 100,000 ft. The whole is easily adaptable to different sized spaces because the panel stands are flexible, but an area of 26 ft. × 26 ft. is recommended.

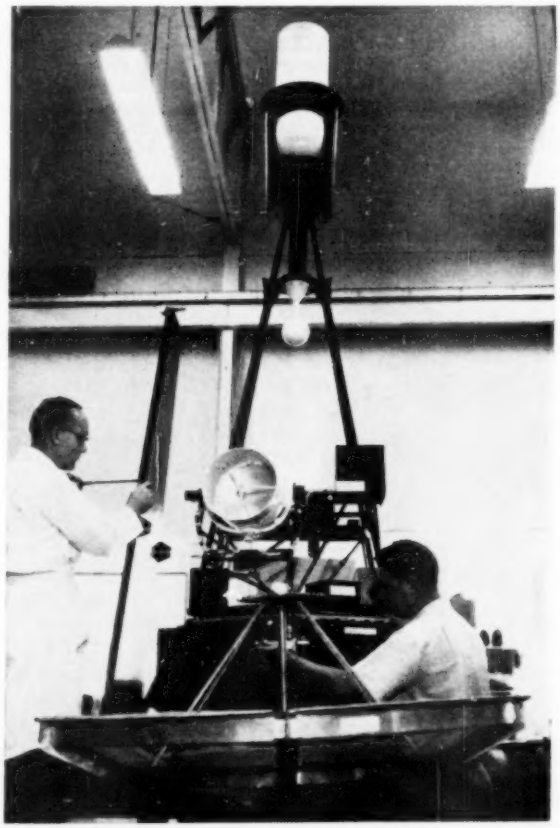
The exhibit can be transported to schools free of charge and staff provided to set up and break it down afterwards. However, a minimum period of 3–4 weeks for display is required and as much advance notice of a booking as possible would be appreciated because there may be occasional difficulty in obtaining transportation at very short notice.

Schools interested in this exhibition material are asked to write for booking forms to the B.I.S. Secretary at 12, Bessborough Gardens, London, S.W.1.

Special Lecture

We are pleased to announce that the Society has arranged an additional lecture for 5 July at 7 p.m. It is entitled "The Use of Satellites for Navigation Purposes" and will be given by Mr. J. D. Nicolaides, Technical Director for Navy Astronautics (U.S.) Bureau of Naval Weapons. Mr. Nicolaides has been associated for some time with the U.S. Navy's Transit Satellite programme.

The lecture will be held in the American Embassy Theatre (entrance in Upper Book Street) Grosvenor Square, W.1, by kind permission of the authorities.



This is a photograph of the mock-up of the 700 lb. Ranger spacecraft which is under development for N.A.S.A. at the Jet Propulsion Laboratory in Pasadena. The technician on the left is working on one of the two solar panels which will supply power to the vehicle's instruments. His companion is adjusting one of the gas-jet reaction controls to be used in maintaining the spacecraft's attitude.

Jet Propulsion Laboratory

FIRST MAN IN ORBIT

Major Yuri Gagarin travels to the launching site in a coach on the morning of his historic orbital flight.

On 12 April a Soviet citizen, Major Yuri Gagarin, became the first man to orbit the Earth. His "Vostok" spacecraft landed safely in a prearranged area in the Soviet Union after a flight lasting one hour 48 minutes. The following notes have been extracted from official Soviet Press statements and news reports made available by "Soviet News."

The world received the news that a man had been launched into space while the flight was actually in progress. These were the words of the *Tass* announcement as they were broadcast over Moscow Radio:

"The world's first satellite spaceship, the *Vostok*, with a man on board, has been put into orbit round the Earth in the Soviet Union on 12 April, 1961.

"The pilot space navigator of the satellite spaceship *Vostok* is a citizen of the U.S.S.R., Flight Major Yuri Alexeyevich Gagarin.

"The launching of the multi-stage space rocket was successful and after attaining the first escape velocity and the separation of the last stage of the carrier-rocket, the spaceship went into free flight on a round-the-Earth orbit.

"According to preliminary data, the period of revolution of the satellite spaceship round the Earth is 89·1 min. The minimum distance from the Earth (at perigee) is 175 km. (108½ miles) and the maximum (at apogee) is 302 km. (187½ miles), the angle of inclination of the plane of the orbit to the equator is 65 deg. 4 min.

"The spaceship with the navigator weighs 4,725 km. [nearly 4¾ tons], excluding the weight of the final stage of the carrier-rocket.

"Two-way radio communication has been established and is being maintained with space navigator Gagarin. The frequencies of the short-wave transmitters on board are 9·019 Mc. and 20·006 Mc./sec., and in the ultra-short-wave range 143·625 Mc. The condition of the navigator in flight is being observed by means of radio telemetric and television systems.

"Space navigator Gagarin satisfactorily withstood the placing of the satellite ship *Vostok* in orbit and at present feels well. The systems ensuring the necessary conditions for life in the cabin of the satellite spaceship are functioning normally.

"The satellite spaceship *Vostok* with navigator Gagarin on board is continuing its flight in orbit."

According to reports received from the spaceship at 9·52 a.m. (Moscow time)—7.52 a.m. B.S.T.—Major Gagarin, while over South America, reported: "Flight is proceeding normally. I feel well."

The following is part of a dispatch sent by "Pravda" correspondents from the area where the Soviet spacecraft landed:

Correspondents on duty took their places at various instruments in the control post, alongside plane tables showing air conditions and a big map with a wide red line indicating the axis of the *Vostok's* flight.

Here was the first report: "She's off! The *Vostok* is airborne."

Then came the first words from Yuri Gagarin, picked up by one of the radio sets: "I see land covered with haze. I feel well."

Reports coming in from all parts showed again and again that the flight was proceeding normally and that the *Vostok* would land at the appointed place.

Time moved swiftly. It seemed as if it had acquired the cosmic speed with which the Soviet spaceship was hurtling through distant substellar space.

We waited for the signal telling us that the braking devices had been actuated in the astronaut's cabin somewhere over there, beyond the clouds, thousands of kilometres away, that the braking had begun and that the spaceship, having left its orbit, was moving towards the Earth, aiming at the spot selected for landing. How exact the calculations for that had to be! The slightest departure by even half a second, half a degree, could add up to a substantial error.

It was 10.15 a.m. Major Gagarin reported from the *Vostok* that he was over Africa and was standing up well to weightlessness. Experts busy with the maps and radio equipment exchanged glances. Everything was fine, everything was going well.

The moment for landing was drawing nearer.

Landing

The control post had received new, adjusted co-ordinates of the *Vostok's* calculated landing point. A glance at the

map showed that the point was very close to the red line—the axis of flight.

One after another, reports were coming in of new fixes of radio signals from the spaceship, which was already on the ground, and planes and helicopters were dispatched immediately to the spot. They were not needed, however. The telephone rang and a happy, excited voice reported:

"Gagarin is with us. . . ."

The call came from a village not far from the landing point.

After landing, the astronaut had not waited for planes to come for him. Feeling fit, he had gone to meet the people who had rushed out to welcome him.

The flight was over.

A helicopter appeared. A few minutes later it had brought the space pilot to the nearest airfield.

A Press conference was held on 15 *April in the Hall of the Scientists' Club in Moscow which was packed with the correspondents of Soviet and foreign newspapers, agencies, radio and television.*

Tremendous applause greeted the young astronaut as he entered the hall and Gagarin, smiling happily, raised both hands in greeting.

The press conference was opened by Alexander Nesmeyanov, president of the U.S.S.R. Academy of Sciences.

Nesmeyanov stressed that the *Vostok* spaceship in which Yuri Gagarin had made his historic flight on 12 April was equipped with everything necessary for his safe flight and return.

Many of the ship's systems had duplicated apparatus to ensure extra safety.

The ship carried instruments which enabled the astronaut to determine his position in orbit with precision at any moment.

A two-way radio link was maintained with Gagarin during the time the ship was being prepared for the start and during the flight.

Stressing his great courage and self-possession, Nesmeyanov said that the night before the flight Gagarin had slept soundly and was awakened a few hours before the launching.

His pulse was 70–75 beats per minute during the preparation for the flight and after the start of the rocket.

When Gagarin was told that the command was being given for the count-down, he exclaimed cheerfully: "Well, here we go!"

The scientist said that even when the ship was being put into orbit, when the powerful rocket engines were working and the astronaut was experiencing the effects of acceleration, vibration and noise, he continued to report not only on how he felt, but also on the work of all the systems in the ship's cabin.

On behalf of the presidium of the Academy of Sciences, Nesmeyanov greeted Gagarin, a great Soviet man, "the Columbus of outer space."

Addressing the astronaut, he declared:

"Centuries will pass, but your name will always remind people of the greatest exploit achieved by Soviet scientists and designers, and by you personally, in putting the first man into outer space. You have shown to all mankind an example of courage, valour ahd heroism in the service of humanity."

He then presented Gagarin with the Konstantin Tsiolkovsky Gold Medal awarded to him by the presidium of the Academy of Sciences for making the world's first spaceflight in the satellite spaceship *Vostok*, a medal struck for outstanding works in the field of astronautics.

Gagarin shook hands with the president of the Academy of Sciences and held up the medal for the correspondents to see it.

Yuri Gagarin then spoke.

He said he was born on 9 March, 1934, into the family of a collective farmer in Smolensk region. Before the 1917 revolution his parents were poor peasants, as his grandparents had been. After elementary school he had studied at a vocational school. He had then gone to an industrial technical school in Saratov, on the Volga.

"But my dream was to become a pilot," he said. "I wanted to fly. Therefore, while at technical school, I attended the Saratov Aviation Club."

In 1957 he graduated from the Orenburg Aviation School as a fighter pilot.

At his own insistent request he had been included among the astronaut trainees.

Before the flight, Gagarin said, he had felt "well, very well, just perfect."

"I knew the equipment; it was reliable, and I, like all my comrades, had no doubt about the successful outcome of the flight."

During the flight, too, he had felt very well. Neither the increased gravitation nor the noise and the vibrations when the ship went into orbit had had any oppressive effect on him. He could work successfully carrying out the programme set for the flight.

Weightlessness appeared after going into orbit and separation from the carrier rocket. At first the feeling was somewhat unusual, though he had experienced it for brief periods before. However, he soon accustomed himself to zero gravity and continued to work on his programme.

In his opinion, weightlessness did not affect the efficiency of the human organism or its physiological functions.

Gagarin declared that throughout the flight he had carried on fruitful work according to the set programme.

"I ate and drank water during the flight," he said. "I maintained contact with the Earth through several channels, using a Morse key and a radio-telephone. I conducted observations of the surroundings, transmitting the results to the Earth."

He also entered the results of the observations in the flight book and tape recorded them.

He felt fine during the state of weightlessness and his working ability had not been impaired.

Gagarin went on to say that the command to land was given at a designated moment envisaged in the flight programme. The ship was oriented, then the braking system was switched on. The landing proceeded as envisaged by the flight programme.

"It was with joy that I saw our Soviet people again," Yuri Gagarin said. "The landing was made in a pre-set area."

Gagarin spoke in detail about the observations he had made in the course of the flight.

"The Earth is seen very well from the altitude of 175–300 km.," he said. "It looks about the same as from a jet plane flying at great altitudes.

"You can easily distinguish mountain ranges, big rivers, islands, the coastline, lakes.

"In cosmic flight it is quite possible to orient the map with the terrain, as the pilots say."

He said he could see the clouds shrouding the Earth very well and their shadows on the globe's surface.

The sky was absolutely dark. The stars in it looked brighter and were more distinct than from the Earth. The Earth itself had a very characteristic and very beautiful bluish halo. This halo was clearly discernible when looking at the horizon. One could observe the gradual transition from a light-blue colour, through bluish, blue, and violet to absolutely black.

"This is an unforgetably beautiful transition," he said.

"When emerging from the shadow," he added. "The sun shines through the terrestrial atmosphere and the entire halo assumes a somewhat different colour. On the horizon

of the Earth I could see a bright orange strip which then goes through all the shades of the rainbow to the dark black colour of the sky.

"The entry into the Earth's shadow is very rapid. Darkness comes instantly."

He said he could see nothing on the Earth at that moment: apparently he had been passing over an ocean at the time. But the stars were very clearly seen. The emergence from the Earth's shadow was also very rapid and sudden.

"I withstood very well the effect of space flight factors thanks to thorough training," the astronaut went on to say. "At present I feel fine."

Gagarin expressed his gratitude to the Soviet designers, engineers and technicians, to all the Soviet people who had built the remarkable spaceship *Vostok*, the excellent equipment and rockets capable of placing huge vehicles in orbit.

To great applause he stated: "We shall make many more flights and with confidence. We shall get down to the conquest of outer space in earnest."

"We are always glad of the achievements of science in other countries," Gagarin added. "We shall be happy to greet the astronauts of other countries in space, to wish them success in the peaceful conquest of the cosmos, and we want to co-operate with them in the peaceful use of outer space."

These words of the astronaut were drowned in applause. Another great ovation greeted his final words:

"Personally, I want to make many more flights into space, I like the experience. I would like to fly to Venus and Mars, to make really big flights."

Selection System

Academician Norair Sisakyan then addressed the press conference, noting that the most important thing in preparing an astronaut for flight was the closest possible simulation of spaceflight conditions in laboratories on Earth or flying in aircraft.

The astronaut's preparation for space flight was a complex scientific problem, he said. Naturally, he must be a man in perfect health with a high intellectual standard and extensive technical knowledge: a man of strong will capable of making sound decisions under strain and carrying them out at once, a man capable of making a quick and correct appraisal of the situation.

Sisakyan, who is academic secretary of the biological department of the Academy of Sciences, said that the astronaut selection system provided for a thorough investigation of the candidates in stationary clinical conditions. Special methods of research were used for this purpose, making it possible to determine sufficiently fully the functional potentialities of a man's organism and its adaptability to unfavourable environmental factors. An important part of the selection system were psychological studies.

The preparation consisted of a study of the theoretical aspects of the future flight, and the training of the astronaut in the use of the equipment, the research instruments, in the spaceship's cabin.

The physical training had been organised with a definite purpose in view: to increase the organism's resistance to acceleration, to train the astronaut to perfection in using his body freely in space, in being able to make purposeful coordinated movements.

The aim was ot increase the astronaut's ability to withstand prolonged physical exertions without any loss of efficiency and to reinforce his willpower.

Professor Vasily Parin, member of the Academy of Medical Sciences, spoke of the preparation of the cosmonaut for his first spaceflight, of his physiological state during the flight.

Having noted that the flight was preceded by sputniks with dogs, mice and other biological specimens, Professor Parin stressed that precisely these experiments yielded important scientific data on the influence of spaceflight factors on the living organism and served to perfect the system of scientific medical control.

The pre-flight training of the cosmonaut, he said, constituted a special problem. Strict medical supervision, special nutrition, systematic investigations on the ground by methods intended for the flight—all this had ensured unity and sequence in receiving the most valuable scientific information.

Medical Supervision

Study of the biocurrents of the brain and muscles and detailed cardiological studies ensured the needed scope and thoroughness of supervision over the cosmonaut's health.

Medical supervision over Gagarin's condition was conducted throughout the entire flight without interruption.

Irrespective of the reports on the health of the flier, received by the doctors and physiologists periodically over the radio from Gagarin himself, they also checked with the help of radiotelemetering his pulse and respiration.

Professor Parin said that simple and convenient pickups were built into the astronaut's space suit. They transformed the biocurrents of the heart, pulse fluctuations of the vascular wall and the respiratory movements of the thorax into electric signals.

Preliminary data, received from analysis of the telemetered information, showed that from the medical viewpoint Gagarin's flight was exceptionally smooth. Pulse and respiratory changes on the active sector of the flight and during the descent were approximately the same as in the course of numerous training sessions. The pulse and respiration became almost completely normal during the state of weightlessness.

He stressed in conclusion that history's first space flight by man had yielded exceptionally valuable data. It confirmed

Clad in his pressure suit, Major Gagarin enters the lift which conveyed him to the *Vostok* spacecraft in the nose of the launching rocket. His single orbit took 108 min. from take-off to landing.

the forecasts of Soviet scientists, not only that man could travel in space, but also that it was possible to preserve his ability to carry out various kinds of work there.

Academician Yevgeny Fyodorov said that the information submitted to the correspondents at the Press conference was only the intial information about Gagarin's flight. Appropriate accounts and other scientific material would be published later.

No Earlier Attempts

Academician Nesmeyanov then announced that the majority of the questions handed in by the correspondents were addressed to Yuri Gagarin and that he would therefore answer only the ones addressed directly to him, the president of the Academy.

He said several questioners asked whether there had been earlier attempts to send a man into space. Some of them referred to reports about this in the western press.

"There have been no such attempts," Nesmeyanov said. "Yuri Gagarin was the first man, and his attempt, as you see, has been crowned with success."

Replying to a question whether it was necessary to send a man into outer space, Academician Nesmeyanov said: "If such a necessity did not exist, how could we then study other planets in general.

"Photographs, like the one of the Moon's reverse side, are not enough. The very presence of so many correspondents in Moscow these days shows that photographs alone do not suffice. You wish to see everything with your own eyes."

Asked why the Soviet Union had outstripped the United States in the exploration of space, he said:

"There are many reasons, as in any complex event. It was in our country that Tsiokovsky lived. Already in pre-revolutionary Russia he had worked out the theory of spac flight, the first.

"But the main reason, in my opinion, is that scientific and technical work can be organised much more purposefully in a socialist state than in a state with private property and a multitude of clashing interests."

Then Yuri Gagarin answered questions.

No Photographs of Earth

He said that in the U.S.S.R. different versions of the landing technique had been worked out, including the parachute system.

During this flight, he said, the pilot was in a cabin and the descent was successful, testifying to the high efficiency of the whole system of landing.

Asked whether photographs of the Earth's surface made from the satellite spaceship *Vostok* would be published, Yuri Gagarin said:

"The spaceship *Vostok* did not have a single camera or photographing device, therefore no pictures were taken and, you will understand, there is nothing to publish."

In reply to another question, Gagarin said that he had not felt either hunger or thirst during the spaceflight. He had felt exactly as on Earth.

The astronaut said that he had been informed in advance that he was a candidate for spaceflight. He had had enough time to prepare for the flight.

He spoke highly of the role of radio communications in spaceflight. Radio had helped him to keep in constant touch with the Earth, to receive commands, transmit information about the work of the equipment, and had given him constant moral support.

He said that he was met almost immediately after landing on Earth.

He added that before the flight he weighed 69½ kg., and he weighed the same today.

The length of the descent amounted to several thousand kilometres, Gagarin went on, pointing out that this could be judged by the fact that the braking device was switched on at 10.25 a.m. and the touch-down was effected at 10.55.

He said that he had never flown in ballistic rockets before.

Asked whether the spaceship or certain parts of it could be used for another flight, Gagarin said that this was for the technicians and engineers to decide.

But in his opinion the spaceship and its equipment could be used again.

Landing Technique

Initially, details of the re-entry and landing procedure were withheld. On 24 April, however, the newspaper *Izvestia* described the spacecraft as consisting of two parts. One part contained the pilot, his pressurized cabin, and the landing equipment. The other housed the retrorocket and other equipment needed in orbit. This follows the procedure already outlined in the description of the earlier dog-carrying experiments (see *Spaceflight*, January, 1961, pp. 9–12)

Izvestia reported that after the spacecraft had descended to a certain height, "the landing apparatus can be switched on, and the direct landing of the pilot's cabin takes place at low speed.

"The landing of the space pilot can take place in the cabin of the ship. Such a landing method was tested in the fourth and fifth Soviet spaceships.

"A variant of this was also foreseen, in which the pilot would be expelled by ejector seat at a height of about four miles, and would land by parachute."

It was also stated that the *Vostok* had three viewing ports and two escape hatches. One of the former was fitted with "direction finding apparatus" to enable the austronaut to determine his position in the event of failure of the ground control system.

In the event of a failure to trigger the retro-rocket, the orbit was so arranged as to cause the spacecraft to re-enter after a few days under the normal influence of atmospheric retardation. For this purpose, the vehicle carried enough food, water, oxygen and electrical supplies, to keep the astronaut alive for up to 10 days.

A photograph has also appeared showing the interior of the spacecraft cabin. Equipment visible includes the pilot's controls; the instrument panel with a revolving globe; a television camera directed at the pilot; a viewing port wth direction-finding apparatus; an orientation control handle; a radio receiver, and a food container.

The Astronaut

Major Yuri Gagarin was born on 9 March, 1934, in the Gzhatsk district of Smolensk region (Russian Federation). At that time his father was a collective farmer.

He first went to school in 1941, but because of the German invasion had to interrupt his studies.

After the end of the war, the Gagarin family moved to the town of Gzhatsk, where Yuri continued his secondary school education. In 1951 he completed the course at a vocational school in Lubertsy, outside Moscow, with distinction, qualifying as a moulder. At the same time he was studying at an evening secondary school for young workers.

Afterwards he studied at a specialized secondary school at Saratov, on the Volga, and in 1955 he passed his final examinations there with honours.

Gagarin took up flying while he was still a student at the specialized secondary school, attending a course of instruction at the Saratov Aeroclub. After completing this course in 1955, he entered an aviation school at Orenburg. Since 1957, when he passed his final examination in the "A" category, he has been a Soviet airman.

He is married and his wife Valentina, who is 26 years old, studied at a medical college in Orenburg. They have two daughters, Elena and Galya, aged two years and three months respectively.

The Probing Eye*

By H. C. KING, Ph.D., M.Sc., F.R.A.S.

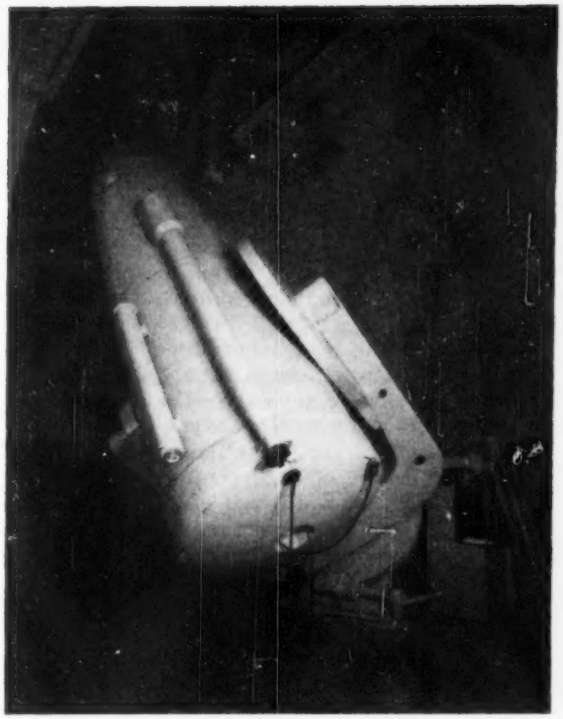
When Galileo in 1609 used one of the first refracting telescopes for astronomical observations he was too preoccupied with the wonders it revealed to worry much about its defects. True, he soon discarded his first instrument (a spy-glass which gave a linear magnification of only × 3) for others of higher magnification. But the increased power was not always accompanied by a corresponding improvement in resolution and image quality.

It is not always realized that in order to see what he did Galileo had to stop down or restrict the effective aperture of his larger telescopes. One of his best instruments gave a linear magnification of about 20. In use its object-glass, of overall diameter 2 in., was stopped down to just over 1 in. The eyepiece, a concave lens, was similarly restricted in effective size. Only by using this expedient could this and other instruments be made to give fairly good images.

We now know that the stopping down procedure used by Galileo helped to mitigate an optical defect called *spherical aberration*.. This is just one of six primary aberrations found in simple lenses and optical systems, and in the case of the telescope it is one of the most important. Much of the history of the telescope, and incidentally, of the microscope also, is the record of a constant struggle to reduce these optical aberrations to within the limits necessary for good imagery. From Galileo's time until the mid-eighteenth century, however, the aberrations were but little understood and the refracting telescope had perforce to be developed along empirical lines. As a result it grew in length, for it was found that best results were obtained when an object-glass had a large focal ratio. The practice reduced the effects of both "false colour," or *chromatic aberration*, and spherical aberration, but at the expense of image brightness.

By stopping down his object-glasses, Galileo gave them focal ratios of about f/50. Later in the same century Hevelius and the brothers Huygens observed with object-glasses of the order f/100 to f/150. Hence when Christian Huygens discovered Titan in 1655 he used a 12-ft. long telescope. Its object-glass had a diameter of only 2 in. and therefore worked at f/72. Before the same observer could be certain of the true nature of Saturn's rings he had to examine that planet with a 123-ft. telescope of 8 in. aperture.

The wonder is not so much that lenses with these high f/numbers were ground and polished three centuries ago but that they were mounted and used as telescopes. Huygens opted for the simplest possible arrangement, mounting the lens in a ball-and-socket universal joint fixed to the top of a high pole. A cord attached to the lens-mount reached to the ground. By pulling on this the observer could both change the attitude of the lens and bring its optical axis in line with his direction of vision. The eyepiece, attached to the observer's end of the cord, usually took the form of a single convex lens mounted on (or supported by) a light adjustable trestle. The entire arrangement, known as an "aerial telescope," was certainly far less cumbersome than that adopted by Hevelius for his 150-ft. telescope. Hevelius mounted the lenses at the ends of a partly closed-in "tube" which took the form of a two-sided wooden "trough." The entire trough, 150 ft. long, was hoisted aloft by ropes and pulleys attached to a high mast. It was kept straight by numerous adjustable secondary ropes, but in view of changes in humidity and weight distribution, these must have required almost constant attention. Moreover, a "tube" so long and slender would quiver like a reed in even the slightest breeze. Preparations for a night's observation doubtless required the services of a whole band of assistants, while the telescope itself, erected in open country just outside Dantzig, attracted crowds of sightseers. Small wonder then that Hevelius used this giant only occasionally, preferring to undertake his lunar



The 48-in. Schmidt-type telescope at Palomar.

* *A lecture given before a meeting of the British Interplanetary Society in London on 3 Dec., 1960, under the title: "The History and Future of Optical Telescopes for Astronomical Observations."*

and planetary observations with shorter and hence more manageable telescopes.

In the same century, Newton's investigations in colour led him to differentiate between chromatic and spherical aberration. In the firm belief that light is always dispersed when it undergoes refraction, and that it was therefore impossible to improve the refracting telescope, Newton invented a reflecting form. This, the Newtonian reflector, gave images comparatively free from false colour, depending as it did on two mirrors and a convex lens. Even so, spherical aberration remained, and to reduce its effects Newton stopped down the eyepiece to almost a pinhole.

Newton made two reflecting telescopes. Both appear to have been about the same in size and both were little more than interesting scientific toys. The first instrument, made in 1668, is now lost. The second, made in 1671, is in the possession of The Royal Society. In the second the primary mirror, of a copper-tin alloy known as speculum metal, had a diameter of 1¼ in. and a focal length of 6¼ in. The instrument therefore works at about f/4·5, is remarkably compact, and gives a magnification of × 35.

The advantages of the Newtonian form were first fully realized in 1721. In that year John Hadley completed an f/10 Newtonian of 6 in. aperture. Tested against Huygens' 123-ft. aerial refractor it proved about equal in definition, but the aerial telescope gave the brighter image. Hadley found it difficult to impart a good polish to the hard, recalcitrant speculum metal used for the mirrors—a problem which the opticians of his century strove hard to overcome. Yet everyone was greatly impressed by the ease with which the reflector could be directed and focussed.

Hadley's reflector had a further advantage: it was fairly free from spherical aberration. It is often thought that a concave mirror must have a paraboloidal and not a spherical surface in order to be free from this defect. While this is true, a mirror of f/10 and higher f/number need not be made paraboloidal to work effectively. In other words, the spherical aberration, although present, is so small as not significantly to impair image quality. This fact has been a godsend to astronomers and opticians, the more so since in the early days of telescope manufacture it was difficult enough to give a concave mirror a good overall polish, let alone bring it to a paraboloidal figure.

Spherical aberration, it should be mentioned, had previously been thoroughly investigated geometrically by Descartes, Huygens and others. All manner of lenses and optical systems free from this defect had been designed, but few opticians, if any, had the technical ability to work the necessary spherical surfaces. In 1663, for example, Gregory proposed a two-mirror telescope in which a primary concave paraboloid collected the light and reflected it to a small ellipsoidal concave which, in turn, formed a secondary image near the centre of the primary mirror. The latter had a hole in the middle to allow the introduction of an eyepiece. Gregory met with insuperable difficulties when he tried to make the aspherical surfaces, as did the London master-opticians whom he commissioned to do the work. Likewise the Cassegrain telescope, another two-mirror combination introduced in principle in 1672, remained in the design stage for many years.

The Gregorian telescope had the advantages that it was compact, operated like an ordinary refractor, and yielded erect images. In the mid-seventeenth century several London opticians, and in particular, James Short, exploited these features commercially. Short, for example, marketed an immense number of Gregorians which ranged in size from giants (for those times) of 18 in. aperture and 12 ft. focus to small instruments a foot or so in length. The larger instruments, few and costly, were reserved for aristocratic dilettantes who used them for anything save serious research. The primary mirrors were parabolized but there is no record of the technique used—a technique which Short guarded jealously right up to the time of his death. He died a rich man but none of his instruments led to any major astronomical discovery. This last fact, encountered all too often in the development of the telescope, is an early example of another important fact—that the scientific value of a visual telescope lies not just in the instrument itself but in the combination instrument and observer. Because of this many a fine instrument has languished for years in a library or observatory without having had a chance of doing useful work.

It was not the Gregorian, however, but the Newtonian which became the accepted optical system for research in sidereal astronomy. This came about through the unflagging efforts of William Herschel, whose desire to penetrate further and further into the sidereal domain led him to construct Newtonians of ever-increasing

Hadley's Reflector.

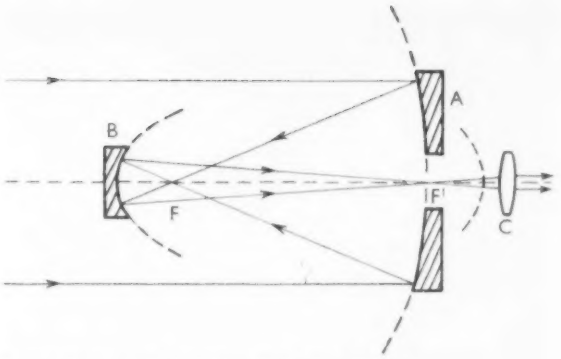
aperture. During the comparatively brief course of 16 years (1773–89), Herschel progressed from Newtonians of 6 in. in aperture to a giant 48 in. in aperture. All these instruments had mirrors of speculum metal, were designed and constructed by Herschel himself, and in his hands led to numerous outstanding discoveries in astronomy.

Lord Rosse of Parsonstown, Ireland, pursued similar studies. Encouraged by Herschel's example and success, Rosse erected in 1842–43 in the grounds of his estate a Newtonian of 72 in. aperture. Some 50 years separated the giant telescopes of Herschel and Rosse, but they had much in common. Both were near failures—at least, they both failed to come up to their maker's expectations. The great size of the specula, or metal primary mirrors, meant that their copper contents had to be fairly high: large discs of low copper content tended to crack during the annealing process or with sudden changes in temperature in the tube. Consequently the mirrors, especially Herschel's, required frequent repolishing and therefore refiguring, work which made great demands on time and energy.

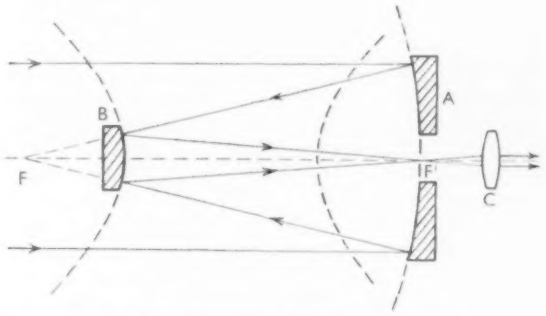
Optical tests were of the simplest. Herschel at Slough tested a 48-in. f/10 mirror by training it on Windsor Castle, some 2 miles away. Rosse placed a watch dial at the centre of curvature of his 72-in. f/10 mirror and examined the image (formed in the same plane as that of the dial) with a magnifier. In both cases final tests on star images took place at night with the mirror mounted in its tube.

Today, optical surfaces are roughed out by carborundum, an abrasive first introduced in 1898. Until then then opticians and others used emery, a far slower-cutting medium. Herschel at first ground and polished his two 48-in. mirrors (one served as a spare) by hand. Handles attached to the speculum enabled twenty-four labourers, in two batches of twelve and under Herschel's directions, to move the great mass over the grinder or polisher. Herschel admitted that this number of workers did not permit "those delicate attentions which are required in polishing mirrors." He later used a mechanical aid, but this had to be manually operated. Rosse ground and polished his mirrors by machinery driven by a steam engine and the operations proceeded fairly smoothly.

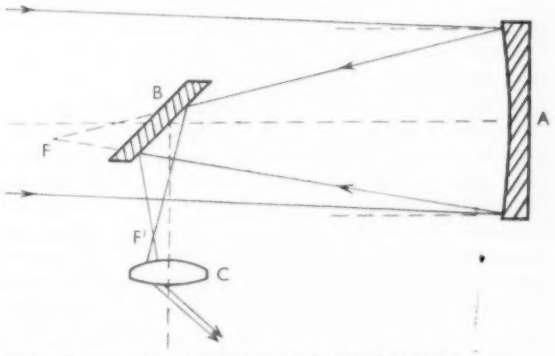
Weather conspired against both telescopes. The mirrors, mounted in iron cells at the lower end of sheet-iron tubes, would sometimes dew over and the dew might freeze. The observer, perched some 30 to 40 ft. above the ground, had perforce to descend to clear the surface. Many times, when the instrument had been prepared for action, clouds would drift over and put an end to the night's plans. Both telescopes were unsuitably located—one near the Thames and the other near the Bog of Allen. Herschel's mirror flexed under its own weight, but Rosse went to some pains to get the load uniformly distributed for all tube elevations. Both mirrors responded uncertainly to temperature changes and required frequent



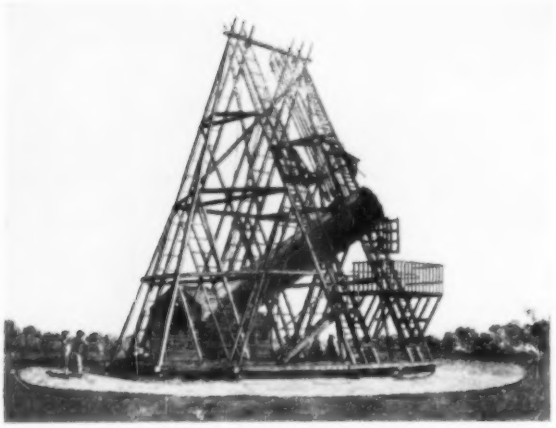
Optical System of Gregorian Reflecting Telescope.
A. Primary perforated paraboloid.
B. Secondary ellipsoidal mirror.
F. Common focus of the two mirrors.
F'. Posterior focus of the ellipsoid and final focus of the system.
C. Eyepiece lens.



Optical System of the Cassegrain Reflecting Telescope.
A. Primary perforated paraboloid.
B. Secondary hyperboloidal mirror.
F. Common focus of the two mirrors.
F'. Posterior focus of the hyperboloid and final focus of the system.
C. Eyepiece lens.



Optical System of the Newtonian Reflecting Telescope.
A. Primary paraboloid with its optical axis shown as a dotted line.
F. Primary focal point for rays incident obliquely to the mirror surface.
F'. Newtonian or secondary focus at the side of the tube.
C. Eyepiece lens.



Herschel's 40-ft. telescope (Engraving).

The Science Museum, Crown Copyright Reserved

adjustment. The mountings were cumbrous and restricted in movement, especially Rosse's which was almost a meridian telescope. The weight of the iron tube alone imposed great strains on the controlling ropes and chains. Other designers profited by these mistakes in design, execution and location, and in this respect the remarkable efforts of Herschel and Rosse proved invaluable to the future course of instrumental astronomy.

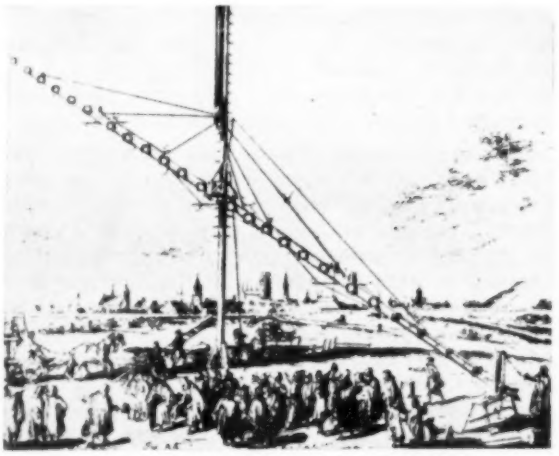
Until Steinheil and Foucault demonstrated the practicability of silver-on-glass surfaces, speculum metal remained almost the only suitable mirror material. The large reflectors built by rich amateurs like Nasmyth, Lassell and De la Rue consequently had metal specula. In 1856 Steinheil made a silver-on-glass 4-in. Newtonian of 8 ft. focus and advertised others up to 12¾ in. in aperture. Foucault in Paris silvered a 33 cm. and smaller mirrors which Eichens (director of the firm of Secrétan until 1867), mounted as equatorial Newtonians. Foucault's largest silver-on-glass mirror, of 80 cm. aperture and 450 cm. focus, was made from a glass disc supplied by the famous St. Gobain glassworks.

Foucault's great contribution to the reflecting telescope was his invention of a simple yet accurate testing technique—the well-known Foucault test. With this ace card he was able to produce glass mirrors equal in definition to the finest object-glasses of the time. His methods, freely given to the world, enabled amateurs to construct their own instruments with comparative ease, an activity which is still highly popular. In America Henry Draper of New York constructed a 15½-in. aperture Newtonian and a 28½-in. Cassegrain. In England, With, Calver, Bird and Key produced between them large numbers of silvered mirrors of from 6 to 18 in. diameter, many of which are still in operation.

Newton's assertion that the dispersive powers of all refracting media are equal went unchallenged for over half a century. In 1729, however, Chester Moor Hall, a barrister with scientific interests, designed the first achromatic lenses. In these the chromatic aberration of a convex lens of crown glass is corrected by that of a concave lens of flnt glass. This is possible because, contrary to Newton's generalization, different refracting media have different dispersive powers. The two lenses can be placed in surface or near-surface contact and yet act jointly as a system with positive power, that is, as a convex lens corrected for "false" colour.

Hall attempted to get various London opticians interested in the regular manufacture of achromatic doublets. He met with no success, despite the fact that a jobbing optician made several achromatic lenses to his specifications. During the process Hall's "secret," if such it could be called, became known to John Dollond, a London master-optician. Dollond promptly investigated the problem of chromatic aberration and its correction, and in 1732 began to make and sell the first worthwhile achromatic telescopes. So great became the demand for them that by the end of the century a trickle of instruments had grown into a flood.

Besides being reasonably free from chromatic aberration, the achromatic doublet could also be so designed as to be corrected for spherical aberration. In the form of a telescope object-glass the combination worked at about f/12 to f/14, a much more convenient focal ratio than hitherto. This brought about a great improvement in instruments like astronomical sextants and quadrants which had been previously fitted with long uncorrected telescopes. Even so, the two-lens achromatic lens still retained some uncorrected colour or "secondary spectrum." This was first satisfactorily corrected in 1763 by Peter Dollond, the son of John Dollond, when he introduced the first triple achromats. These object-glasses consisted of three lenses mounted in juxtaposition and designed so that their dispersive and focal powers



Erecting the Hevelius 150-ft. telescope at Dantzig.

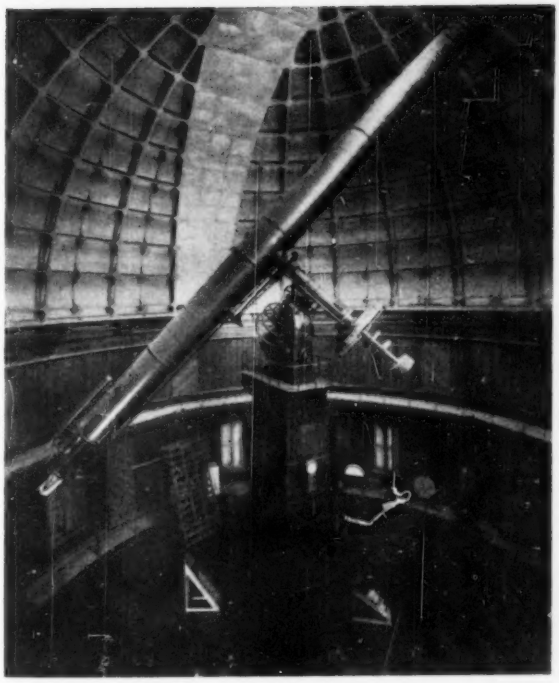
corrected the secondary spectrum. Peter Dollond's triple achromats were of high optical excellence, but owing to the scarcity of good optical glass blanks, especially of flint-glass, none exceeded 4 in. aperture. After Dollond's death, in 1820, triple achromats gradually disappeared from the market. Later telescope-makers like Fraunhofer, Cooke and the Clarks used doublets for their large refractors, and it was not until the late nineteenth century that Dennis Taylor and Howard Grubb reintroduced the triplet in its modern form.

It is significant that out of the hundreds and perhaps thousands of 3- and 4-in. aperture telescopes which the firm of Dollond distributed over Europe, and even America, few led to any important advance in astronomy. Some passed to rich dilettantes; others, once the novelty had gone, were stored away in attics. Comparatively few were used on a course of regular astronomical observation. Thus Schwabe of Dessau, after years of painstaking observation with a telescope of only 1-in. aperture, added more to knowledge of the Sun than did the users of a hundred Dollond 3½-in. triple achromats.

In 1830 the largest refractor in America was a 5-in. Dollond achromatic which Loomis and Olstead used in one of the towers of a college at Yale University. American astronomers had to rely on European instruments; the equipping of new observatories was an expensive adventure and necessitated a visit to opticians in London, Munich and Paris. Hence Fraunhofer of Munich supplied the 12-in. Cincinnati object-glass in 1842, and Merz and Mahler, his successors, the 15-in. equatorial refractor for the Harvard College Observatory in 1847.

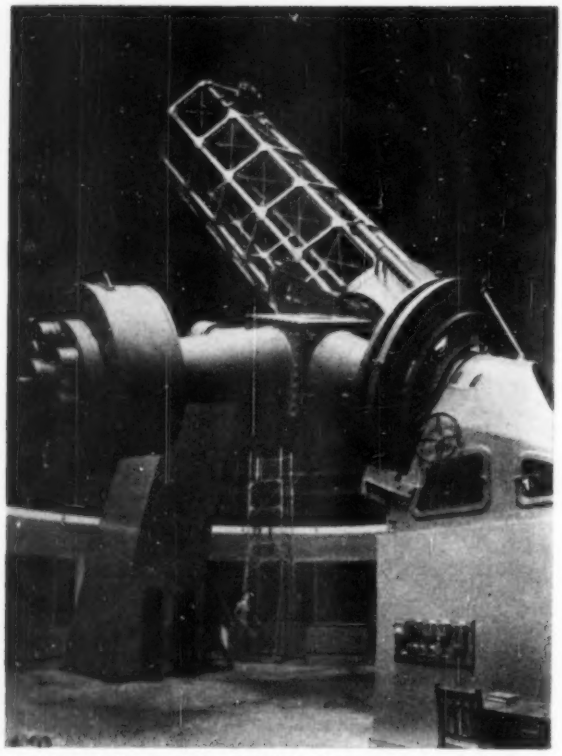
This dependence on instruments of European manufacture was a sore point to many practically-minded Americans, especially since the 15-in. Harvard object-glass alone cost $12,000. Alvan Clark probably felt in this mood when he was granted a few minutes with this refractor. He was a portrait painter by profession but knew enough optics to recognize imperfections in the Merz objective. His reaction was to close his studio and by working on old lenses to master the art of figuring optical surfaces. Aided by his two sons, George and Alvan, he became America's foremost telescope-maker. Progressing through refractors of 18½, 20, 26 and 30 in. aperture, Alvan Clark and Sons finally made the 36-in. Lick and 40-in. Yerkes objectives, so far the largest lenses of their type.

In England, Thomas Cooke pursued similar activities, operating from the first telescope factory in England—the Buckingham Works at Bishopshill, Yorkshire. Starting with a few workmen and one apprentice, Cooke made in a short space of time nine equatorial refractors from 8 to 10 in. in aperture, and twelve others from 5 to 8 in. in aperture. His largest telescope was the 25-in. Newall refractor at Cambridge, an undertaking so immense that it overtaxed his strength and was largely responsible for his death in 1868.



The 36 in. Refracting Telescope at the Lick Observatory, Mt. Hamilton, California.

Until about 80 years ago telescopes were designed to function as visual instruments. Increases in aperture led to corresponding increases in both light-grasp and resolving power, or the ability to resolve fine detail. The same increases required larger and more massive telescope mountings, so that the telescope-maker perforce had to be at once an optician and an engineer. Yet several amateur astronomers, inspired by the work of Herschel and Rosse, undertook almost single-handed the construction of giant telescopes. At Bradstones, near Liverpool, Lassell started with a Newtonian reflector of 9 in. aperture, built a 24-in., and then a 48-in. He was the first to apply the German-type equatorial mounting to large reflecting telescopes, a form of mounting previously applied only to refractors after its introduction (in its modern form) by Fraunhofer of Munich. Lassell was also the first to dispense with the solid form of metal tube in favour of one of latticework construction. By doing this he not only effected a great saving in weight and material but also secured a well-ventilated tube. Solid metal tubes in reflectors are notorious for inducing internal air currents which often play havoc with image definition. Some years later, in 1879, Common erected a 36-in. Newtonian in his garden in Ealing and planned an even larger instrument of 60 in. aperture. But by



The 74 in. Reflector at the Radcliffe Observatory, Pretoria, South Africa.

this time it was all-too evident that the construction and use of a giant telescope, whether reflector or refractor, was beyond the capabilities of a single individual.

It was also evident that many large telescopes (and small ones, too) were most unfavourably located. Until fairly recent times astronomers had an unhappy knack of placing telescopes and observatories in most unsuitable locations. It was, of course, natural that amateur astronomers should build their telescopes in their own gardens and grounds. Professionals too, invariably worked in or near large cities which, a century or so ago, were reasonably free from industrial haze and artificial lighting. Nowadays the proper location of a large telescope is rightly regarded as a matter of paramount importance, and many observatories, especially those on mountain tops, are geographically far removed from their city-based parent institutions.

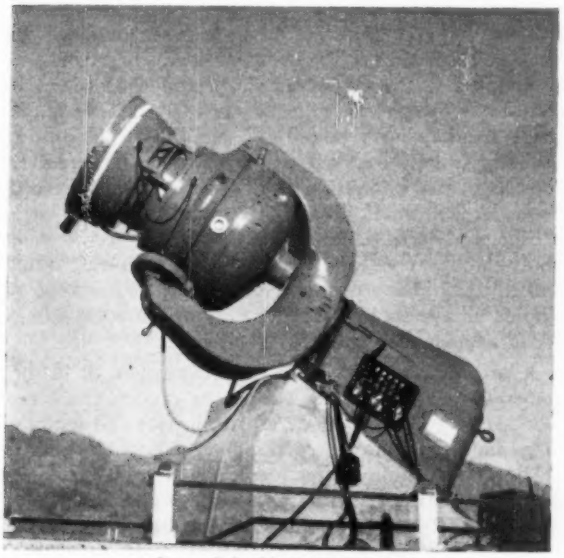
The close of the nineteenth century saw also the rapid rise of astronomical photography. As early as 1882, Gill, working at the Royal Observatory, Cape of Good Hope, had produced striking photographs not only of the great comet of that year but also of the background of stars. He used only an ordinary portrait camera, strapped to a clock-driven equatorial telescope. He realized straightway that here was a simple and quick way of charting the sky: with lenses of different focal lengths he could obtain charts with different scales, with longer and longer exposures he could reach ever fainter stars. Many astronomers became quite expert in this short-focus photography of the sky. Ordinary portrait-type photographic lenses covered comparatively large areas of the sky and gave reasonably good definition over most of the plate. The work reached its first culmination in 1927, when Barnard published his splendid photographic atlas of regions of the Milky Way. This atlas, the result of over 20 year's work at the Yerkes Observatory, was made possible with a 10-in. f/5 Bruce doublet especially designed for the purpose.

Pioneers in the field of long-focus or large-scale astronomical photography were Fitz and Rutherford in the United States, the brothers Henry in France, and Howard Grubb in England. All were new to the subject of photographic lenses and had to undertake considerable experimental work, yet all made good progress in the design and construction of photographic refractors. Nor was astronomical photography restricted to direct work in the primary focal plane of a telescope. It invaded the fields of spectroscopy, stellar photometry and stellar parallaxes, thereby completely changing the time-honoured discipline of visual observation. Many a large refractor was found to be not rigid enough for photographic work. The cost of optical conversion and mechanical reconstruction often proved prohibitive and the instrument had to be put to instructional uses or even scrapped. In some cases the addition of a photographic correcting lens (as with the 36-in. Lick telescope) gave a one-time visual refractor a new lease of active life. In others (like the 40-in. Yerkes refractor) the use of a special filter mounted slightly in front of the focal plane enabled the instrument to be used for direct photography. Of course, many large refractors are still used visually but usually for the measurement of double stars and study of planetary markings.

The reflector, on the other hand, is readily suitable for photographic work in that its elements reflect light of all wavelengths to one and the same focus. Curiously enough, it was Common's 36-in. telescope which established the reflector as the future weapon of astrophysical research. This particular telescope had been purchased by Edward Crossley of Halifax, England, who presented it to the Lick Observatory. Howard Grubb refigured the mirror and Keeler at Lick so improved the original mounting as to make the instrument a most efficient astronomical camera. Keeler's remarkable photographs with it revealed for the first time the existence of an immense number of either very small or very distant nebulæ, whose appearance suggested that they were galaxies similar to our own. We know now that he was recording the faint images of galaxies external to our own—of vast systems of stars similar in general pattern and content to the galaxy in which the solar system is embedded.

In view of the photographic excellence of the Crossley

telescope it was not surprising that a few years afterwards G. E. Hale should decide to build for stellar studies a reflector of the then great size of 60-in. aperture. This telescope, erected in 1908 on Mount Wilson, was the first of the optically-versatile giant reflectors of this century. Although the primary mirror was a complete disc, that is, it had no central hole, the instrument as a whole was designed to function as either a Newtonian or a Cassegrain. As a Newtonian the focal length is 25 ft. and the f/5 focus can be used for direct photography and low-dispersion spectrography. To convert the instrument into a Cassegrain the Newtonian flat is removed and replaced by a convex hyperboloidal mirror. This reflects the light from the primary mirror to focus behind that mirror, but before the secondary focus is reached a third mirror (in the form of a diagonal flat) sends the light beam to focus finally at the side of the tube. This second "elbow" arrangement, often called a Coudé-Cassegrain, gives an f/number of f/16 or, when an alternative convex secondary mirror is used, f/20. In yet a fourth arrangement, where the light is made to travel along the polar axis, the instrument works at f/30. The availability of four optical systems considerably widens the range and scope of the observational techniques which can be employed with one and the same telescope. The 100-in. Hooker reflector, the largest telescope on Mount Wilson, is built on similar lines. Besides the Newtonian focus of 42 ft. the optical layout makes possible either an f/16 Coudé-Cassegrain or an f/30 Polar-Cassegrain form. The 200-in. Hale telescope on Palomar mountain is no less versatile, there being two Cassegrain forms. Instead of having a Newtonian focus, however, the instrument is provided with an observer's cage which gives permanent access to the primary focus. By using this the observer can take the fullest possible advantage of the mirror's great light grasp and comparatively low focal ratio (f/3·3). In this telescope the primary mirror has a central hole and each secondary convex mirror can be swung in or out of position by remote control.



A Super-Schmidt meteor camera.

In an ideal telescope, point objects like stars should be reproduced as point images over the entire field covered by the photographic plate. This is far from being realised at the primary focus of a large reflector. While star images on and around the optical axis take the form of fairly neat, round discs, those further afield are affected by the extra-axial aberrations coma, astigmatism, curvature of field and distortion. The useful field is therefore seriously restricted unless an additional optical element is interposed between the mirror surface and photographic plate. In practice this takes the form of a specially-designed plano-convex lens placed just over the plate emulsion; this lens acts both as a "corrector" and "field-flattener" in that it reduces the coma and astigmatism and causes the star images to have their maximum definition on a nearly-plane surface.

Even when this device is used, star images are still fuzzy blobs, and this despite the theoretically high optical resolution of even the 200-in. telescope. They appear so because of light scatter in the photographic emulsion and turbulence in the Earth's atmosphere. However well a telescope may pass its tests in an optical workshop, it has in the observatory to operate on wave-fronts previously distorted in their passage through the atmosphere. These wave-fronts undergo still further distortion by currents and/or layers of air of varying density in the observatory dome and telescope tube. Small wonder, then, that during an exposure time of minutes, and, quite often, hours, a star image wanders over a small area and records itself as a blur with indenifite boundaries. Clearly, then, a good telescope will perform better if it can be operated at a high altitude or, best of all, when it is in the vacuum of space. This was in part demonstrated by the high-definition photographs of the Sun's surface taken in the course of the recent Project Stratoscope. A 12-in. Newtonian reflector, sent by unmanned balloon to heights of about 27 km., recorded on 35-mm. film the solar granulations, and with a definition sharper than that obtainable from ground level during the very best moments of seeing.

Two-mirror telescopes need not posssess uncorrected coma. In 1905 Schwarschild introduced a number of coma-free or aplanatic two-mirror forms, among them a Gregorian. In the latter the mirrors depart slightly from conoids. The system is best suited to focal ratios of about f/3: spherical abberation, coma and curvature of field are corrected but astigmatism remains. Few have been bold enough or perhaps skilled enough to construct large telescopes of this form and only two (of 12-in. and 24-in. aperture) are in existence. Schwarschild also designed an aplanatic Cassegrain which Chrétien re-introduced in 1923. This works at about f/7, has near-conoidal surfaces, and requires a slightly

concave photographic plate. The last is necessary to allow for curvature of field: astigmatism is small and coma and spherical aberration are absent. Chrétien's design interested Ritchey, chief optician on the 60-and 100-in. Mount Wilson projects, who made two large Chrétien reflectors of 20- and 40-in. aperture. An alternative to the Schwarzschild Gregorian is one proposed by Couder of the Paris Observatory. Couder computed the curves of the primary and secondary concave mirrors of a Gregorian to give zero astigmatism on a curved focal surface. This means that during exposure the plate must be either "bent" to this curve by a suction device or preceded by a "field flattener" in the form of a plano-convex lens.

These forms are now out-dated by the Schmidt system which in its basic form consists of a concave spherical mirror and a weak lens or "correcting plate." The system is a remarkably simple one. Consider, in the first place, a concave mirror with a circular stop aperture placed at its centre of curvature. If the stop aperture has a diameter smaller than that of the mirror (in practice the ratio is 2 :3), and if every ray of a parallel bundle of rays passing through the aperture falls on the mirror, the reflected cone will be quite symmetrical. A straight line from the centre of curvature and drawn parallel to any given ray of light can be regarded as an axis of the mirror, an axis of symmetry. There is no coma, no astigmatism, no distortion—only spherical aberration and curvature remain. As is well known, Schmidt replaced the stop aperture by an aspherical plate which acted as both a restrictive aperture and a corrector of spherical aberration. Curvature alone remained, requiring for its "correction" either film or plate "bent" in a convex film holder or used flat behind a plano-convex field flattener.

In the basic form of the Schmidt the corrector introduces a small degree of chromatic aberration in an otherwise achromatic system. By constructing a paired correcting plate of crown and flint glass, achromatization can be achieved, but the idea has, as yet, received comparatively little attention. Ideally, of course, the corrector should face all groups of oblique parallel rays squarely: it does so only for rays parallel to the axis. This again effects the otherwise perfect extra-axial images of distant objects in monochromatic light. Again, the absorption and reflection of light by the corrector occasions light losses. These can, however, be reduced by giving due attention to transmission characteristics and by the use of coated or "bloomed" surfaces. Several large Schmidts (and small ones also) now have coated correctors made of glasses with good transmissivity in the violet and near ultra-violet.

It will be appreciated from the foregoing that the basic Schmidt is at once a wide-angle and photographically rapid system. The very first of its kind, made by Schmidt in 1930, was an f/1.75 system with a corrector 36 cm. in aperture and mirror 44 cm. in diameter—dimensions usually stated as 36 cm. × 44 cm. for convenience. With this instrument Schmidt amused himself and his colleagues by photographing the inscriptions on tombstones in a nearby cemetery. Turned to the sky it photographed the stars with a previously unknown sharpness over a field as large as 16° angular diameter. Today, the largest basic Schmidt is the 48 × 72 in. f/2·5 Schmidt on Palomar Mountain. This operates with plates 14 in. square, each one covering a sky area of about 36 square degrees.

There is now a wide variety of Schmidt-type telescopes in regular and most successful use. By adding a secondary convex mirror the basic form becomes a Schmidt-Cassegrain. Of these, as J. G. Baker first showed in 1940, there are several versions which are aplanatic and also compact [*i.e.*, the ratio (overall length): (equivalent focal length) is comparatively small]. They can be designed so that flat plates can be used either in front of or behind the primary mirror (but not in one and the same instrument). A large Schmidt-Cassegrain is the 32 × 36 in. f/3·75 telescope which Perkin-Elmer made for the joint observatories of Armagh, Dunsink and Harvard. This covers a field nearly 5° wide on circular 9½-in. diameter plates. Located at Bloemfontein, South Africa, is is playing a most important role in the study of southern skies.

In the basic Schmidt the corrector takes the form of a nearly plane-parallel plate with one face slightly aspherical. Its optical effect can, however, be produced by a zero-power meniscus lens. This alternative was first investigated in 1940 by Bouwers of Delft, Holland, and shortly afterwards, but quite independently, by Maksutov of Moscow. The lens usually has steep spherical surfaces but is fairly easily worked if the optical blank is previously moulded to the requisite shape. It therefore gains over the Schmidt in ease of construction and also in shortness of tube length. When the f/number is f/1 or less, however, the Schmidt gives the better relative imagery. In its basic form the system gives curved fields, but it can be adapted to the Cassegrain form and used with flat plates. For high performance at low f/numbers the single meniscus is replaced by two nearly concentric meniscus lenses. In one design, by Barker, the corrector consists of two concentric zero-power menisci balanced about an achromatic lens. This form is found in each of the six super-Schmidt cameras used for meteor photography at various locations in the United States and Mexico. Each camera has an effective aperture of 12¼ in., an aperture ratio of f/0·82, and can cover a field 55° in angular diameter.

A large number of Schmidt-type telescopes, or better, cameras, are now in regular use in observatories the world over. Even so, modern astrophysics also requires large-scale photographs of the highest possible optical resolution—conditions met only by using telescopes which have large apertures and work at f/16 and higher f/numbers. It will be appreciated that the 200-in. mirror of the Hale reflector, working at f/3·3 forms images of

extended objects which are ten times larger than, say, those formed by a 20-in. mirror of the same f/number. In addition, and with other things being equal, the image of the Moon formed by the 200-in. will show far more detail than that formed by the smaller mirror. It is primarily for this reason that the Lick Observatory now has a 120-in. reflector (the second largest telescope in the U.S.A.), the Royal Greenwich Observatory, Herstmonceux, is to have a 98-in. (designed for work in the Cassegrain and Coudé forms) and the U.S. National Astronomical Observatory an 80-in. and a 36-in. reflector. In Europe, the largest telescope is the new 102-in. reflector of the Crimean Astrophysical Observatory and plans are well advanced in the U.S.S.R. for an even larger reflector 236 in. in aperture.

Yet increases in size would be of little avail if unaccompanied by advances in observing techniques. For example, the resolving power of a photographic telescope depends not only on its aperture but also on the grain size of the plate emulsion. Emulsions which although extremely fine-grain give good contrast and high sensitivity have obvious advantages in astronomical photography. Also important are plates sensitized to specific parts of the spectrum. It is clearly an advantage to photograph reddish stars and complexes of emission nebulosity and interstellar dust with red-sensitive plates just as it is to photograph bluish stars with blue-sensitive plates. Yet it would be wrong to suppose that a photographic telescope could record ever fainter stars merely by increasing the time of exposure. This is true up to a point—a point reached when the background sky contributes so much light as to fog out extremely faint stars. Owing to this restriction, and to give just one example, rapid blue-sensitive plates exposed at the f/3·3 focus of the 200-in. telescope for periods longer than 30 min. (and on one and the same part of the sky), fail to record additional star images. This restriction occurs regardless of the introduction of more rapid optical systems and more sensitive photographic emulsions.

In order to reach beyond the photographic threshold astronomers turn to electronic devices. A photoelectric photometer, for example, makes possible the accurate photometry of galaxies well beyond the photographic limits of even the 200-in., but with the restriction that it covers a very small part of the sky at a time. Most encouraging in this field is the recent progress in image intensification by electronic means. Various forms of image intensifiers have been applied to telescopes and have made possible a decrease in exposure time with no apparent loss of definition. Unfortunately, the image intensifiers developed so far intensify not only star images but also the intensity of the sky background. Even so, ways may yet be found of filtering out this background luminosity electronically. Where the photography concerns stellar spectra rather than the stars themselves, Schmidt-type optical systems have obvious advantages. When a slitless spectrograph is attached to a telescope, the telescope itself behaves as if it has the f/number of the camera lens used in the spectrograph. By using solid-Schmidts for this purpose f/numbers of f/0·35 are practicable: hence one of these used with the 200-in. telescope for slitless spectrography gives an f/0·35 system 200 in. in aperture!

As to the developments in the immediate future it is clear that present trends will continue—that research in stellar astronomy will centre around large photographic reflectors of either the classical or Schmidt-type forms. There is a great need for instruments in this class, especially for work in the southern hemisphere. Each one will doubtless be as large and as optically versatile as funds permit and will invariably be complemented by a separate and smaller telescope as equally well mounted as the larger. The refractor too, will continue to play an important role, but in forms which will bear little resemblance to the traditional equatorial. The tower-telescopes, coronagraphs, and Zeiss-fixed-eyepiece monochromators used in modern solar research, and the zenith-tubes used in time-keeping, witness to the remarkable adaptability and immense development of an optical device which began its career as two separated lenses. Yet in its basic optics a modern telescope with, say, a spectrograph attached, is just a series of lenses, mirrors, prisms, gratings and stop apertures. Representatives of just two or three of these elements now comprise the optics of some of the most powerful instruments of modern astronomical research. The spectroheliograph, for example, as developed by Hale in 1891–95, is in essence composed of slit apertures, lenses and prisms. The coronagraph, invented by Lyot in 1930, is basically a series of lenses with an interposed circular stop. The Schmidt camera, as we have already seen, consists of a lens and a concave mirror. One wonders how otherwise it is possible to combine these elements to produce new systems—systems which may well guide the pattern of astronomical research in the future.

No optical telescope, located at or near the bottom of an ocean of air, can be expected consistently to give of its best. Give its mirrors adequate ventilation, make them of materials of high thermal diffusivity, figure their surfaces with great accuracy, mount and guide them with precision by remote control—yet over all presides the atmosphere with its optical vagaries and restrictions. High-altitude observatories usually (but not necessarily) provide the best observing conditions but the solution lies in the development of either some device which can constantly "flatten out" the distorted incident wavefronts, or ways of operating telescopes *in vacuo*. Recent developments in space research indicate that the second alternative is the one most likely to be realized—and, we hope, in the not-too-distant future.

Reviews

1001 *Questions Answered About Astronomy*. By James S. Pickering, Lutterworth Press, 1960, 420 pp., 17s. 6d.

The introduction on the dust cover of this book states that it is a very readable, comprehensive encyclopaedia. It also suggests that it should be an essential to every bookshelf devoted to astronomy and will also be an invaluable introduction for the beginner.

The title is somewhat puzzling as there are actually 1049 questions and answers—it is sub-divided into 15 chapters covering such subjects as, The Sun, The Earth and Moon, Motions and Eclipses, Galaxies, Radio Astronomy, Instruments, etc.

The print and presentation are excellent: the clear line diagrams, although rather sparse, are very good with clear and concise explanatory captions. There are 16 half-tone plates grouped together in the centre of the book, but except for a small photograph of the reverse side of the Moon, all are reproductions of astronomical photographs seen in most of the well-known books on the subject.

One cannot find fault with the grouping of the questions and, although naturally very brief, the answers are adequate, whilst a comprehensive and detailed index assures immediate reference to every topic.

There is a brief chapter on Astronomers from Thales to Einstein which might have been more satisfactorily positioned at the beginning of the book; however this book should become recognized as a standard book of reference and a book that everyone interested in astronomy ought to possess.

S. W.

Race for the Moon. By Martin Caidin, William Kimber (London), 224 pp., photos, paintings, line drawings, 36s.

This is the British edition of an American book which first appeared on the other side of the Atlantic about a year ago. Its author has produced several earlier good popular works on spaceflight, notable for the quality of the illustrations by his collaborator, Fred L. Wolff. Some excellent black-and-white reproductions of paintings by this artist appear in the present book, together with many fine photographs from Cape Canaveral, and a number of line drawings, some of which are rather crude; the book as a whole is very well produced.

Its main theme is the "race" between the Americans and the Russians to send the first rockets to, nearby, or around, the Moon. On the American side, this consisted of the Operation Mona, or Pioneer, programmes, with launchings over the period August, 1958, to March, 1959. First, the U.S.A.F. made three attempts with Thor-Able vehicles, having a solid third stage, and a rather sophisticated payload capsule which incorporated retro-rockets in the ambitious hope of achieving a satellite orbit around the Moon. The first of these attempts suffered an engine failure of the Thor bottom stage, after 77 sec. of flight; on the second, there were velocity and trajectory errors which limited the flight to one of 71,000 miles into space, from which very valuable scientific results were nevertheless obtained. On the third, the solid third stage failed to ignite on separation.

The U.S. Army then entered the lists, with their Juno II vehicle, consisting of a Jupiter bottom stage with three upper stages of clustered solids; rather less ambitious than the Thor-Able, no retro-rockets were fitted and nothing more than a close approach to the Moon was intended. The first Army attempt had a result almost exactly similar to the second Air Force one, and achieved a flight of 63,000 miles into space. The second, however, in March, 1959, passed within 37,000 miles of the Moon. Christened Pioneer IV, it earned for von Braun and his Huntsville team the distinction of having launched the West's first lunar rocket, just as they had its first Earth satellite (the Redstone Explorer I).

Alas, two months before, the much larger Lunik I (or Mechta) had won the "race" for the Russians, who went on (with Luniks II and III) actually to *hit* the Moon, and to photograph its back side. Subsequently, the Americans achieved a further success with the Thor-Able Pioneer V, but this was not a lunar shot, rather an interplanetary probe; then there were several unhappy failures with Atlas-Able lunar shots, the last of them fairly recently.

Caidin's book is a well-written account of all these endeavours, with occasional digressions to debate the value of lunar bases and spaceflight in general, conditions on the Moon, and other astronautical matters. One thing the lay reader should get from the work is some feeling for the tension and drama, and the necessary preparations, of rocket launchings; all this is described in detail (indeed, in some places with so much detail as to threaten, but not quite achieve, tedium), and although some of the accounts are rather highly coloured, it must be admitted that the message does get through. After all, scientists and engineers who have worked for months on an experimental rocket may perhaps be excused for screaming "Go, go, go . . . you sonofabitch!"

The author is to be congratulated on his fair and accurate account of Russian achievements, as complete as reliable published data permit it to be. He severely takes to task those of his countrymen who seek to belittle the Soviet feats, suggesting that some of them may have been faked, or that their scientific, as opposed to political, value was small. Mr. Caidin wisely refuses to partake of these sour grapes.

An interesting historical sidelight of the book is a description of Project Moon. In early 1955, Caidin, with his artist-collaborator, Wolff, was apparently working as a special consultant (for what, one wonders) to the Commander of Cape Canaveral. They submitted a proposal to the authorities for a large four-stage lunar vehicle. The original twin-chambered rocket booster for the ramjet Navaho missile would have been the first stage; the second would have been a Redstone, and the third and fourth, unspecified solids. Nothing came of the scheme, but no doubt it contributed something to the stream of thought, like so many other preliminary project investigations.

A. V. Cleaver.

Rocket to the Moon. By Erik Bergaust and Seabrook Hull.

There have been many books published under titles similar to this one, some scientifically rational and cautious, others pure fantasy. This book deals with its subject at a very topical moment and one might prepare to read incautious statements and to find distortions arising through lack of perspective. That the co-authors work within the events they describe increases the likelihood of distortion. In fact, to this reviewer, the book seems very confused and very disappointing. But there is a difficulty here, in that it is hard to appreciate the success or failure of a book when there is a prejudice against the point of view. The authors adopt an outspoken military point of view—and this will find many opponents.

The first few pages attempt to justify flight in space. This is surely a task very few would attempt—that is, to justify scientific endeavour. The military reasons advanced (and repeated) appear important simply because the others are less tangible—yet, probably, the military reasons, while valid, are least important. In pursuing their arguments the authors analyse the political, administrative and technical

aspects of the "race to the Moon" in detail and with unnecessary repitition. The remaining one half of the book, roughly, is devoted to flight to the Moon more specifically.

Unhappily those parts dealing with spaceflight and astronomy are disordered and mixed with speculation, close to fantasy. Three sequences, each covering many pages, relate events associated with the launching of a rocket. The first two are "science-fiction"—the first manned lunar rocket leaving the Earth and the launching of a military transport to the Moon are described. One feels one has read it all before somewhere. In the last chapter we have a description of the first attempt made by the U.S.A.F. to launch a lunar probe (fact). Here the authors succeed. The chapter is interesting and inspiring, in a breathless sort of way, and the spirit of the Pioneers is caught.

But, in general, the book is very frustrating. No single aim is apparent and carelessness prevents any developing. Could this be the greatest danger of co-authorship? Frustration, too, comes from the effort needed to unravel meaning from an excess of words. We stop to delete "human complex" and to substitute "man"; again to replace "actuate pulverizing" with "pulverize." We puzzle over "space instrumentalities." We query "supra-international." In short, "gobbledegook" makes the book much fatter than it ought to be.

There is much quoting from scientific authorities and this seems excellent practice. Even here though facts are distorted and misprints appear. The lunar density is given as 0·06 that of the Earth (p. 26); the parallax of Alpha Centauri is stated as 1 min. of arc (p. 69); the spin rate of the Juno II probes is given as 400 revs./sec. (surely not). We read on p. 73 that the Moon's orbital inclination varies from $+5°$ to $-5°$ in 18·6 years—does this mean that half the time the Moon moves in a retrograde orbit? Radioactive temperature sounds a little curious (p. 139). Is it reasonable to include, as a motion of astronautic concern, the expansion of the universe (p. 73)?

Some of the less speculative parts of this book may be of interest to the less exacting reader. This reviewer cannot recommend the book.

K. Fea.

Nothing on Earth

An appraisal of the current trend in science-fiction writing, by M. VERTREGT

Science fiction is as old as science itself. As soon as men had made the first scientific discoveries, there were those who looked beyond the established facts and let their thoughts roam in the world of Fantasy.

Though the science of the Homeric Greeks was not much to speak of, they already had their ideas about self-propelled vehicles, thus anticipating by some 3000 years the invention of the automobile.

Speaking of Hephaistos, Homer says:

"That day no common task his labor claim'd:
Full twenty tripods for his hall he fram'd
That plac'd on living wheels of massy gold,
(Wondrous to tell) instinct with spirit roll'd
From place to place, around the blest abodes,
Self-mov'd, obedient to the beck of gods. . . .

Even robots were not outside Homer's fantasy:

"With his huge sceptre grac'd, and red attirre,
Came halting forth the sov'reign of the fire:
The monarch's steps two female forms uphold,
That mov'd, and breath'd, in animated gold;
To whom was voice, and sense, and science given
Of works divine (such wonders are in heav'n!)"

—(Ilias XVIII 440–445 and 486–491,
translated by Alexander Pope, Gentleman.)

As science developed, the scope of science fiction expanded too, and the flowering of Greek science in Alexandria gave us the first story of interplanetary travel in Lucian's Ikaromenippos. As a result of the work of Aristarchos of Samos, educated people at that time were already familiar with the idea that the planets are worlds.

Later in the Middle Ages, when Aristotle was the infallible authority in the Christian world, and also as a consequence of the acceptance of Ptolemy's system with the Earth as the centre of the universe, belief in space travel died out.

If the stars, the planets and the Moon are not material bodies, but, as Aristotle learned, only immaterial glimmerings of light, then obviously space travel has no sense. But as soon as Copernicus had dethroned the Earth and reduced it to the role of a common planet, and had re-established the Sun in its rightful place, the idea of voyages to other worlds revived. Soon the new ideas of Kepler, Bacon and Galileo broke through, and Kepler's "Somnium," Bishop Godwin's "The Man in the Moone," and Cyrano de Bergerac's "Histoire comique ou Voyage dans la Lune," are examples of this newer kind of science-fiction.

The methods these authors proposed to reach the celestial bodies are mostly very curious: flocks of trained birds, dew drops, and artificial wings are among them. But on the other hand, for the first time rockets appear timidly on the scene.

When people at length got an idea of the distances between the planets, when they learned that hundreds of thousands of miles of absolute vacuum separate them from their nearest neighbour in space, the fancy for space travelling cooled considerably.

Then the fabulous development of the sciences in the nineteenth century gave a new impetus to this kind of literature. The outstanding science fiction writers of that century were Jules Verne and H. G. Wells.

It is a curious fact that there is a sharp difference

between the spirit of science fiction before and after Wells, reflecting the development of science before and after Einstein.

Nowadays, Wells' stories, half a century after they have been written, are as fascinating as ever, while the science of Jules Verne seems old-fashioned and slightly ridiculous. Numerous scientific developments with which everyone is now familiar, such as the internal combustion engine, nuclear power, radio and television, are outside the scope of Jules Verne's fantasy. For us, Wells is still a modern writer, while Jules Verne is antiquated. He would be long forgotten but for his unforgettable characters like Captain Nemo, Hector Servadac, Phileas Fogg, Robur the Conqueror, and many others.

With the tumultuous development of the sciences in our time, an equal stormy development of the volume of science fiction has taken place; a veritable flood of this kind of literature has sprung up and goes on without any sign of abating. The great quantity of the œuvre implies that the quality will be rather mixed. It is sad to relate that in the deluge of present-day science fiction, masterpieces are few and far between, and that the world would be hardly worse off, if 95% of it had never been written.

As "science" is the slogan nowadays, many authors think is sufficient to introduce a few scientific terms into a story to make it science fiction.

They concoct a conventional love story about a young hero and a damsel in distress; they shove in a few atomic guns and spaceships to make it "scientific," and in order to give it a local colour they set the scene on planet X of system Y. Then they invent a series of "battles, sieges, fortunes, accidents and hairbreadth 'scrapes'" to fill the pages and a new science fiction story is born.

It would not make the slightest difference if the scene of such a story were laid in Ruritania, Earth. It would be just as bad.

This particular brand of science fiction is called Space Opera. It is the "science" fiction for schoolboys, chock full of romance, young heroes, beautiful maidens and bad scoundrels, everything, of course, liberally larded with sex. Despite the fact that the mental age for this kind of literature lies in the vicinity of 13 years, there is apparently a great demand for it, particularly in the U.S.A.

It is a pity that many good writers, who have produced some excellent stories, occasionally succumb to the temptation to earn an easy dollar by writing trash for the multitude. This "in-and-out running" makes it difficult to judge the literary merits of an author. Ironically, some of the worst stories are written by the best authors.

Fact and Speculation

In order to be able to act as guide to the reader in this Science Fiction Jungle, the present writer intends to look into the question as to what constitutes the difference between a good science fiction story and a bad one. The first conclusion one arrives at is that "science" is not the most important part of a science fiction story. Science is only a means to an end. In good stories the science is kept on the vague side and remains in the background.

Nobody can predict the course of science for even a few years in advance. Positive predictions are often rendered out of date in a short while and then they look ridiculous. It tickles our sense of ridicule when we read in a nineteenth-century story about airships, driven by steam engines which cleave the air at the terrific speed of 60 m.p.h. When all is said and done, Man's fantasy is rather limited. Truth is always stranger than fiction.

The real aim of literature is the study of Mankind: his thoughts, his emotions, his conduct, his reactions to uncommon circumstances. And science should be introduced in fiction only to create these uncommon circumstances.

On the base of scientific facts an author can imagine the most queer, weird and fantastic circumstances, and he can observe the antics, the squirmings and the posturings of his experimental homunculi like a God from high. Human dignity, valour, love and loyalty can change quite suddenly into their opposites under trying conditions. The vagaries of the human mind will always procure the most absorbing situations, and this source will never be exhausted.

Although the development of existing sciences, and especially an overdevelopment, a *reductio ad absurdum*, will often create interesting complications, most writers judge it safer to seek their subjects not in established ideas, but in more problematical cases on which there is still not agreement.

Such subjects are, for instance, parapsychology, telekinesis, relativistic dilatation of time, time travelling and other controversial points, on which it is possible to build all kind of pseudo-scientific hypotheses and theories. Good science fiction writers have the knack of discovering the weak points of science and to spin an interesting yarn around them, to imagine an unexpected possible development of a well-known scientific fact, or to give an unexpected solution of an unsolved problem of contemporary science.

It is inevitable that every science fiction story shall contain some measure of improbability. It wholly depends on the ability of the writer to make this improbability acceptable. A reader of science fiction, in order to enjoy a story, should concede that nothing is impossible in the future.

There have been many learned persons who demonstrated with scientific arguments that flying is impossible, that looking through solid objects is impossible, that the transmutation of materials is impossible, so now we are a little wary and not at all so forthright as our forbears in declaring any fantastic prophesy to be impossible.

But still, science fiction should not be too improbable. One can lay down the rule that just as a dog is permitted

by law one bite in his lifetime, so a science fiction writer should be permitted one improbability per story.

And this is, in fact, the difference between a good and a bad writer. The good writer builds his story on one improbability (which at the end of the story seems quite probable, thanks to the skill and insidious suggestive powers of the author); the bad writer piles one improbability upon the other as often as he has to extricate his hero from a tight spot.

Often the improbability is not so much in the science as in the technological application. For the technical-minded reader it is a little difficult to accept the notion of an old German professor building single-handedly a complete Moon rocket in his back room, or of a drunken genius constructing a Time Machine from a can opener and a few bits of copper wire.

Technical feeling (and elementary mathematics) are not always the strongest virtues of science fiction writers.

Subject Assessment

Considering the unlimited and variegated scope of science one would expect the scope of science fiction to be equally diversified. But obviously not all facets of science are equally attractive and in reality only a rather small number of subjects is used extensively.

The present author has made a study of more than a thousand short stories and novels, and has found that 90% of the subjects can be placed in the following nine categories:—

		%
1.	Interplanetary Travel	14
2.	The Future of Mankind	12
3.	Extraterrestrial Invasion of the Earth	12
4.	Extraterrestrial Life	12
5.	Mutants/Mental Developments	11
6.	Interstellar Travel	10
7.	Robots	8
8.	Terrestrial/Interplanetary/Interstellar War	6
9.	Time Travel	5
	Total	90

Interplanetary travel is already on its way to becoming a practical reality and logically stands at the centre of interest.

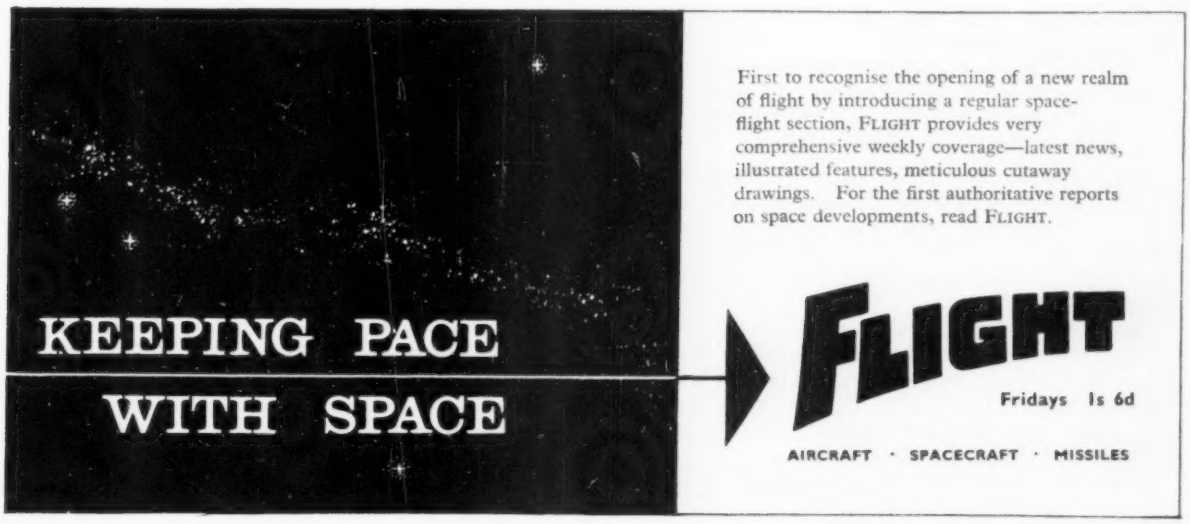
Though some writers, whose fantasy soars higher, rather despise this topic as too commonplace, some very good stories have been written about Man's first visit to the Moon and to Mars. I need only mention Heinlein's "The Man who sold the Moon," and Eric Maine's "High Vacuum." Of course, Wells' "First Men in the Moon" is still unsurpassed.

Visits to the planets are more remote in time, but it is a curious fact that already a kind of tradition exists as to the circumstances on the planets.

Despite the opinion of astronomers that Venus is a practically waterless desert, and that its atmosphere consists chiefly of carbon dioxide, Venus is invariably represented as a soggy, waterlogged, tropical world. The inhabitants are weak harmless creatures who live amphibiously at the waterfront.

Notwithstanding the excess of water, the planet seems to be especially suitable for agriculture, and many small farmers emigrated from Earth hoping to find a new and better world there, only to fall into the hands of rich pitiless capitalists, who exploit them mercilessly and who maintain their power by the services of a cruel secret police.

Every reader of science fiction knows that Mars is populated by little green men, who possess strange


KEEPING PACE
WITH SPACE
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powers and who have a great civilization behind them. Ray Bradbury's "The Martian Chronicles" is an illustration of the thesis that it is possible to write good science fiction with practically no science.

Although the asteroids have no atmospheres and cannot have atmospheres because their gravitational force is too small to retain gases, this fact does not present some science fiction writers from having their lonely hero, aided by a gang of robots, cultivate his plantation on some asteroid, until a beautiful girl turns up to relieve his solitude.

For Space Opera writers the asteroids are, of course, a godsend, as they are ideal hide-outs for their space pirates.

It takes some imagination to colonize the planet Jupiter with its 2½ times Earth gravity, its unfathomable poisonous atmosphere of methane and ammonia, and its raging hurricanes which attain velocities of thousands of miles per hour. But it can be done, witness Clifford D. Sim's excellent story: "City."

Less bizarre are the circumstances on the moons of Jupiter. A. C. Clarke has written a clever story about the most intriguing one of the royal planet's twelve moons, Jupiter V.

The remaining planets excite little interest, except, remarkably enough, the farthest one, Pluto. This planet seems to be rich in precious minerals, which are mined by colonists working under the most terrible circumstances. These minerals must really be very precious to make the enterprise profitable, for the journey to this planet last some tens of years!

Time Travel

Interplanetary travels are not strictly impossible with present technological means, but interstellar and intergalactic voyages are out of the question; and so the science fiction writers can give their fantasy a free rein to invent means for bridging the unimaginable distances of the Cosmos. The most remarkable methods are proposed, like using curvatures in space, so that places which are millions of light years apart, still may be situated close together. Furthermore, the hypothetical relativistic dilation of time is naturally an inexhaustible source of ideas for the science fiction writer.

Time travelling in science fiction is an agreeable pastime. A great advantage of this mode of transport is its cheapness. According to almost all authorities it consumes practically no energy, so that a million years travel into the future costs no more than a single day's trip.

The usual procedure is that you enter a kind of cabinet; you push a button, and off you go to the future or to the past. The fact that only living matter is transported, so that your clothes are left behind, and you enter the future stark naked, adds an extra touch of adventure to the pleasurable excitement of time-travelling.

As there is absolutely nothing in present-day science that could lead to time travelling, sensible authors do not try to explain their time machines. Therefore, various technical gadgets in the shape of spinning wheels, mirrors and glowing crystals are only embellishments of the story, and strictly not to be taken seriously.

The implications of time-travelling are bizarre in the extreme, for instance, meeting yourself in the future or in the past. One of the most entertaining of these stories is John Wyndham's delightful tale: "The Chronoclasm."

Robot stories can be very entertaining, but most writers are apt to overdo it. If a creature thinks like a man, reacts like a man, feels like a man, why call him a robot? There are stories about robots which read like "Romeo and Juliet," not omitting the death-bed scene. Such a story, and a very well-written one, is Richard Wilson's, "If you were the only."

The Future of Mankind is naturally a great concern to science fiction writers. The frequency of subjects such as Extra-Terrestrial Invasion of the Earth, and Terrestrial/Interplanetary/Interstellar War, reflects this anxiety. And here we see especially that the outlook of the American authors is exceedingly glum.

Even if everything on Earth is not wholly annihilated by atomic war, Man's lot in the future is far from enviable. Utopias are not fashionable nowadays: Wells' "Modern Utopia" was the last one. After World War I people do not believe any more in a Utopia, and the word is used only in an ironic sense, as in Huxley's "Brave New World," and Vonnegut's "Utopia 14." The world of the future will in no sense be a Utopia, according to most present-day science fiction writers. They have little trust in the hallowed principles of democracy. The government of the future is mostly in the hands of evil dictators, who rule with the aid of a cruel Secret Police. Of course, the good principle must be victorious and the bad dictator invariably comes to a very bad end, but this does not deter the others, and the supply of new dictators never gives out.

Alternatively the government is in the hands of a bunch of greedy, blood-sucking plutocrats, who sweat and enslave the poor colonists on Venus.

It seems that our struggles for freedom, for justice, for social security have all been in vain. According to authorities like Pohl *et al.*, technological progress will not ameliorate the lot of our descendants, and the people of the future will live in a worse serfdom than during the Middle Ages.

And even if he is not oppressed by masters of his own race, he is certain to fall a prey to the bloodthirsty inhabitants of Sirius X or any other planet with a highly developed science. For, this is a maxim in American science fiction—every race anywhere in the universe that has attained space travel and nuclear power, automatically strives for world domination.

This widespread cultural pessimism of the American writer is a remarkable phenomenon, and though the opinions of an author's characters do not necessarily

reflect his own opinions, the trend is too universal to be accidental.

Amiable Monsters

The greatest part of science fiction literature is written in the English language, but there is a very distinct difference between the stories of British and of American origin. Life in British stories runs quietly, even on other planets, and under the most strange circumstances. The style of the stories is mostly subtly ironical; nothing is taken too seriously.

Against this, the American story is violent and in dead earnest. In British stories, even murderers are amiable people, and so are the monsters from outer space. They are mild, harmless creatures, who would not hurt a fly, quite unlike Van Vogt's Coeurl, who chews chunks of high alloy steel like so many pieces of candy.

In American stories everything is done violently. The hero is always slamming down the telephone, cramming his hat on his head and jamming the brakes of his car; and all this slamming and cramming and jamming is to show the world what a splendid tough fellow he is—toughness being the most admired quality in the American male.

Of course, all American heroes are sturdy individualists: the small shopkeeper, who has his hot-dog stand on Mars, the small merchant who sells his aluminium pots and pans on Sirius X, the small farmer who tills his land on Venus.

It is really astonishing how unimaginative and hide-bound the American science fiction writer can be on the subject of social developments, in contrast to his exuberance in technological matters. Travelling faster than light?—why not? Intergalactic wars?—sure! But . . . social justice, a government without corrupt politicians, "cops" who are not sadistic brutes? Impossible, sir! Absolutely out of question!

Social abuses which have been abolished since long in civilized countries, still exist in the year A.D. 5000. Planets are exploited in the same manner as the Western powers exploited their colonies three centuries ago. When it comes to political and social changes, time stands still for American science fiction. All things on Earth are transitory and perishable, but the drugs store on the corner will last for ever.

The art of writing funny science fiction stories is very difficult, and such efforts are seldom to be recommended. Many writers have not yet discovered that there is something between slapstick comedy and high tragedy. I must make an exception in the case of Fredric Brown's, "Martian, go home." Though slapstick is not missing, the story is in general truly humourous and well written. But the pearl goes to Britain's A. C. Clarke for his "Tales of the White Hart" which deserves to become a classic of humorous science fiction, next to some of H. G. Wells' short stories.

Now that we are on the subject of extraterrestrial invaders, it is the place to point out that there are two distinct schools of thought about the shape of these invaders.

Some authors, and especially those who write Space Opera, take the simplest way out and depict extra-terrestrial humans as a faithful copy of terrestrial people, down to the smallest detail. It is gratifying to learn that the Hollywood standards of beauty and behaviour for girls are respected even in far-away worlds. The fair maidens of planet A of system Z are as cute as our pin-up girls, and do not lack in sex appeal.

Other authors think it necessary to provide a bit of local colour by giving the extraterrestrial race a few peculiarities. But as a story is unsalable if there is no love interest in it, small differences in the girl's physiological make-up, like green hair or an extra eye, only enhance her attractions. Even the fact that the loved one lays eggs is no obstacle in the path of True Love, and cannot prevent the founding of a happy family.

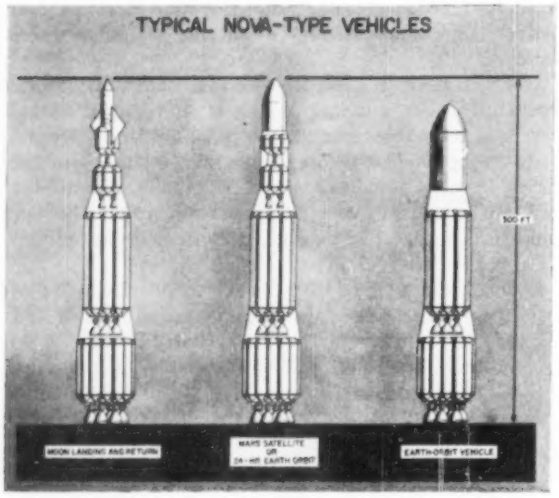
The other school of thought is of the opinion that the human form is only accidental and that the chance of its being repeated elsewhere in the universe is negligible. This provides the opportunity to give imagination free play and to parade a host of monsters of every conceivable shape and form.

From Wells' Martian Octopuses and Selenian Ants, we come to creatures who breathe fluorine and who have silicon, instead of carbon in their bodies. We meet beings who have no fixed shape, like amoebae, beings who have no individuality of their own, but are part of a common organism. We meet intelligent earth-worms, intelligent slugs and intelligent plants. It is in this domain that the good science fiction writer can show his mettle.

To promote sales, science fiction pocketbooks are adorned with brightly-coloured covers. The picture on the cover has mostly practically nothing to do with the story, a scantily dressed young lady being the most prominent feature. Aesthetically it is generally of such a low quality that the publisher does not think it worth while to mention the name of the artist.

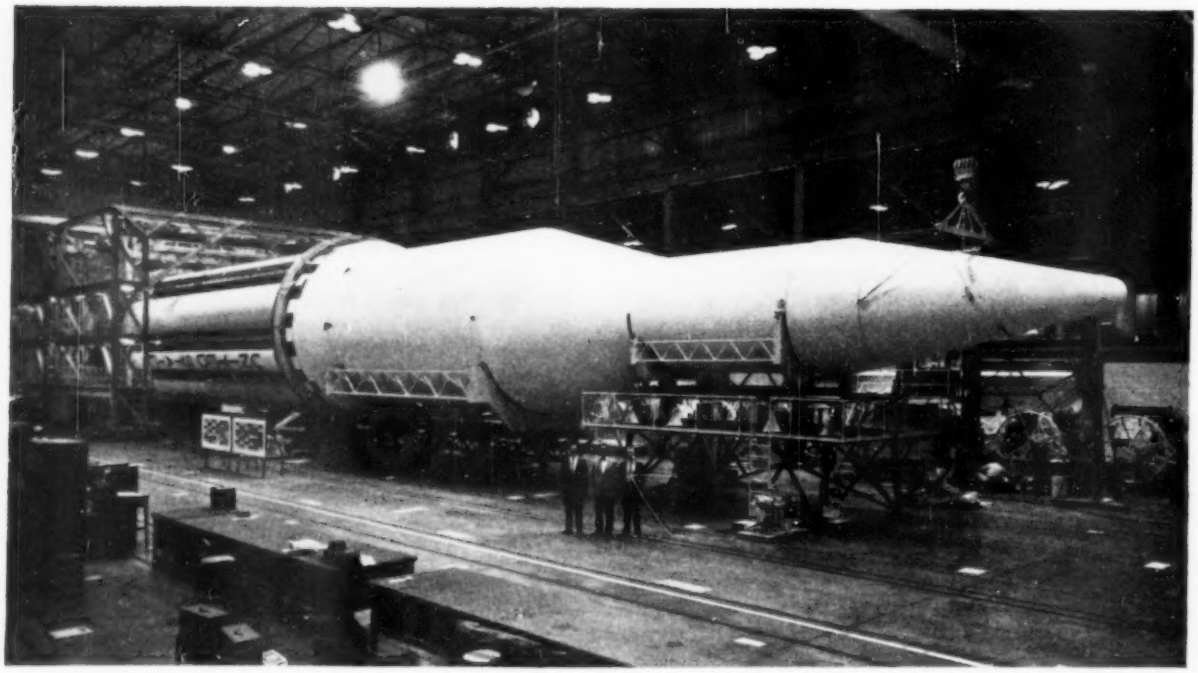
A pleasing exception is made by the fantastic covers, designed by Richard Powers, which are a joy to behold. These unearthly shapes can mean anything: they may represent buildings, machines, trees, beings—no one knows. In these pictures Mr. Powers shows what many of the bright boys who fill the inside do not always seem to realize, namely, that things on other planets look like nothing on Earth.

The Big Boosters . . .



Rocketdyne's single-chamber F-1 rocket engine of 1·5 m. lb. s.t., ready in 1963, may be clustered to provide launching thrusts from 9 to 12 million pounds. This would make possible (*a*) a two-way mission to the Moon, with a lunar landing; (*b*) a 200,000 lb. space-station in close-orbit around the Earth; and (*c*) a 90,000 lb. space-station around Mars.

North American Rocketdyne



First flight-weight version of the 1·5 m. lb. s.t. eight-engine Saturn booster is seen in the Fabrication and Assembly Engineering Division of N.A.S.A.'s George C. Marshall Space Flight Centre, Huntsville, Alabama. Dummy second and third stages are attached.

National Aeronautics and Space Administration

A "Sit-Me-Down" Spacesuit

Despite a great deal of work backed by experience with kits for high-flying airmen, a satisfactory spacesuit has not yet been produced. A short list of the most recalcitrant problems would include the following: (1) Mobility: The suit must be flexible enough to permit bending and easy movement of the arms and legs with not greatly less than 3 lb./sq. in. internal oxygen pressure and vacuum outside. (2) Thermal insulation: The suit must be capable of protecting the wearer from ambient temperatures between at least some 120° C. and – 150° C. —these being approximately the maximum day and minimum night temperatures attributed to the Moon. . . . In fact, however, much greater extremes may be encountered, not only on the Moon but whilst engaged in, say, space station construction at Earth's orbital distance from the Sun.

To no small degree these two prime requirements obviously conspire against one another. Moreover, if the suit is intended for protracted periods of use, further problems arise in connection with eating and drinking, disposal of the body's waste products, replenishment of air-conditioning units, and arrangements for resting during longish absences from a spaceship base or mother vehicle. The accompanying photograph shows a "working model" mock-up of a "Moon-suit" produced by Republic Aviation Corporation scientists in an attempt to solve the difficulties mentioned above.

By way of explanation I quote from the only information I have—a 7 October, 1960, Press release by Carl Byoir & Associates, Inc., for the Republic Aviation Corporation:

> "The suit consists of a two-piece cylindrical aluminium tunic and torso with legs and arms attached.
>
> "The dome-shaped top section is encircled by a fourteen-inch-high window. Within the aluminium capsule there is the radio communication unit, the air conditioning and oxygen supply controls, lifting handles, resting seat, food storage bins, waste storage bins, searchlight control and electrical power supply.
>
> "On trips of long duration, the lunar explorer can rest himself this way: he lowers the legs of a tripod stand affixed to the outside of the suit 'around the hips,' and draws up his legs and sits on a small shelf inside the suit."

This very meagre information coupled with the maniest immaturity of the design makes comment difficult. Moreover, I am an amateur with only the background of a 1940 spacesuit design of my own to match against Republic's experimental resources and team of scientists. I hope, therefore, that my unsolicited criticisms will be taken in good part and not precipitate the consternation which might ensue if my opinions were those of a rival concern.

The lunar exploration suit exhibited by Republic Aviation Corporation.

Carl Byoir & Associates, Inc.

My first criticism is that the suit is very bulky. Even just one would take up a lot of room in a spaceship of "foreseeable" size. However, they could be shot into orbit and collected there or delivered to the Moon by telecontrolled or robot freighter. If this sort of spacesuit really did its job, I think bulkiness is not a fatal objection.

One specific claim for the design, according to the rather unhappily worded press release, is that "the suit is meant to be "working clothes" for an astronaut as he scouts around, digs, gardens, or does other chores on the Moon." In the picture the wearer is in fact holding a small pick and trowel. Now though I can visualize our astronaut applying his tools to a rock-face in some geological research, I defy him to get close enough to the ground under his feet to pick up anything, or, with the short implements depicted, engage in lunar "gardening." I not only defy our tinned spaceman to kneel down because his tripod is in the way, I defy him to get up again if he falls over.

I am also under the impression that the arms and legs of the presently exhibited suit would be far too rigid under operating conditions. And the thermal insulation

of the footwear is manifestly inadequate to afford protection against lunar ground temperatures.

Another point is that the cylinder shows no evidence of being double-walled, or lagged—in consequence the wearer, especially whilst resting, would be liable either to frost-bite or burning by contact with the shell.

This last criticism can I think also justly apply to the panoramic window. Not only must it be double-walled for safety's sake but so large a "heat-window" would, I fancy, afford a very high rate of "night-loss" or "day-gain" of heat—perhaps, even with the best barrier transparency, so great as to impose an altogether prohibitive load on the suit's temperature stabilizing gear.

No mention is made in the press release as to how the cylinder is kept in position, but I assume that shoulder-harness is used. And I also take it for granted that provision would be made for warming or cooling the gloves.

Again, I assume that the tripod legs will be furnished with "feet" as a precaution against sinking, and perhaps sinking unequally, into soft lunar ground.

An omission which surprises me is that no provision is made for the disposal of waste from the suit. In my own non-rigid design (*J.B.I.S.*, Jan., 1950), where the arms could be withdrawn from the sleeves, I proposed a small air-lock in the "puter-pigeon" chest. Republic's space-suit seems to afford opportunity for the advantageous incorporation of this feature.

Incidentally, my suggestion to cater for rest periods in the case of a non-rigid suit, was to provide a shooting-stick type of seat and a very light folding camp-bed.

H. E. Ross.

"Blackie" Returns

The Soviet Union on 9 March successfully put in orbit and brought back to Earth a 4½-ton spaceship carrying an experimental dog and other biological specimens. It landed, on command, in a prescribed area of the Soviet Union. The dog, named Chernushka (Blackie), is quite well and normal after its orbital flight.

The *Tass* news agency gave the following account of the flight:

"In pursuance of its space programme, the Soviet Union put a fourth spaceship satellite into an orbit round the Earth on 9 March, 1961. The weight of the spaceship is 4700 kg., not counting the final stage of the carrier rocket.

"The vessel followed an orbital path close to the calculated one, its lowest limit being 183·5 km. (about 114 miles) and its highest limit being 248·8 km. (about 155 miles) from the Earth. The inclination of the orbit to the equator was 64° 56′.

"The main object of this launching was the further improvement of space vehicle design and equipment to ensure conditions for man's flight in space.

"The satellite ship carried a cabin with an experimental animal—a dog named Chernushka—and other biological specimens, as well as telemetric and television systems, a radio system for trajectory measurements and radio communication apparatus.

"The instruments carried by the vessel functioned normally during the flight.

"After fulfilling the set research programme the vessel landed on command in a prescribed area of the Soviet Union on the same day.

"The initial inspection of the vessel after landing proved that the experimental animal was in good condition.

"As a result of the launching of the fourth Soviet satellite ship and its successful recovery from the orbit, valuable data have been obtained on the efficiency of the structure of the ship and its system, and also on the nature of the influence flight conditions have on living organisms.

"The data obtained are now being studied and processed. The biological specimens which made the flight are under constant observation."

The *Tass* science correspondent points out that the main purpose of the launching was similar to that pursued by previous launchings of heavy spaceships, in particular of the second spaceship in which the dogs Belka and Strelka and other biological specimens made a flight into space last August.

In this way, he says, the Soviety Union is carrying out a systematic programme of checking and developing all technical flight and recovery systems.

Another spacecraft, containing the dog Zvezdochka (Starlet) and other biological specimens, was sent into orbit on 25 March and safely recovered. This was followed by Major Yuri Gagarin's orbital flight on 12 April.

Correspondence

Sir,—With reference to John W. Macvey's article on "Craters of the Moon," the very large size of some lunar craters suggests escape of gas and water through sand and silt. The boiling and perhaps icing could supply the flattening and expanding forces, in some cases probably superimposed on a caldron subsidence (ring fault subsidence). Interested persons are referred to:—

1960 Iain A. Williamson, "A Spring Pit with Mound Structures," *Proc. Geologist's Assn.*, Vol. 71, Part 3, p. 312.

1928 Dr. F. Oswald, "A Mud Volcano in the West Caucasus," *Geological Mag.*, Vol. LXV, p. 494.

1927 Prof. E. H. L. Schwarz, "Caldrons of Subsidence," *Geological Mag.*, Vol. LXIV, p. 449.

C. M. Heanley.

Sir,—An article in the *St. Louis Post-Dispatch* with the title, "Meteor Trap Proposed to Find if We Might Really be Martians," caught my eye. It suggested the launching of a meteor-catching satellite to test a theory that life arrived on earth from another planet.

What surprises me is why this should be necessary. A number of years ago, I read where it was done—not by catching the meteors out in space—but by the simple process of grinding or breaking up the unburnt part of meteorites that had survived their flight through space and atmosphere and had been dug up. This news item stated that bacteria spores and germs *did* exist in recovered meteorites.

Has any reader knowledge of this?

Gilbert Vondrasek.

Missouri, U.S.A.

THE BRITISH INTERPLANETARY SOCIETY

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THE BRITISH INTERPLANETARY SOCIETY

THE BRITISH INTERPLANETARY SOCIETY was founded in 1933 to promote the development of astronautics—interplanetary exploration and communication—by the study of rocket engineering, space medicine, astronomy, navigation, astrionics and other associated sciences. Its membership is international and includes most workers prominent in these fields.

The main work of the Society consists in the publication of two periodicals (free to all members); in the publication of books and monographs; and the organization of scientific and technical meetings. In addition to symposia and meetings at which original research papers are presented, lectures, exhibitions, visits to research establishments and film shows are held to explain to the lay public the progress that is being made in astronautics and the ultimate implications to human society of the crossing of space.

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(*b*) To receive copies of *Spaceflight*, a quarterly non-technical magazine, and other publications issued from time to time.

(*c*) To attend all lectures, meetings, symposia, exhibitions, and film shows arranged by the Society.

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The general requirements for Fellowship are any one of the following:

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(*b*) Corporate Membership of a recognized professional Institution.

(*c*) Considerable contributions to the development of astronautics.

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(*b*) Graduateship of a recognized professional institution.

(*c*) Higher National Certificate, or an equivalent.

(*d*) An examination qualification equivalent to Inter. B.Sc. or Ordinary National Certificate, *plus* five years' relevant scientific or industrial experience.

Applicants for election to Associate Fellowship under Clause (*d*) above must not be less than 25 years of age. Applicants for election under other clauses must be over the age of 21 years.

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Applicants for this grade must have been members of the Society for a period of seven years.

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